Contrasting sleep: Infants and adults

Laura Nauha[a], M.Sc. (Health Sci.), Doctoral Researcher,
Hannu Kinnunen[a], PhD

[a]Nucu Oy, Finland

Infants' sleep fundamentally differs from that of adults. There are major differences in overall sleep need and duration as well as in the structure and timing of sleep. Moreover, sleep-wake patterns develop continuously through childhood until they become fairly static in adulthood. By understanding and supporting infants' sleep, one also supports the caregivers' sleep and their energy levels, which has been suggested to be a beneficial method to promote positive parenting and better responsiveness to infants' needs. This white paper starts by summarizing the differences between adult and infant sleep. Next, it presents physiological mechanisms that explain why infants actually sleep as they do, and finally, it gives science-backed tips for healthy sleep practices for families.

Keywords: *infant sleep, adult sleep, sleep rhythm, wellbeing, circadian rhythms*

Comparison of adult and infant sleep

Why do adults only sleep at night? When a person has been awake long enough—usually for 15 to 16 hours for adults—they will get tired and it will be easy to fall asleep. Additionally, adults have a 24-hour cycle of alertness that makes them most sleepy in the early morning hours (3–5 am) and highly alert in the early evening, even after being awake for about 12 hours. These two phenomena can generally explain the daily sleep-wake rhythm of adults. Science calls the first phenomenon the sleep-wake homeostasis, and the latter two examples result from the circadian system (Bathory and Tomopoulos 2017). In brief, sleep-wake homeostasis drives the body toward sleep after extended

wakefulness, and the circadian system regulates about a 24-h sleep-wake cycle and high alertness timings. These systems do not behave similarly in infants: infants become tired after shorter periods of wakefulness, and toddlers still require regular naps. Furthermore, infants and most toddlers can usually fall asleep easily during the day as well.

Infants require a lot of sleep but frequently wake up due to hunger, discomfort, or the need for parental care. In fact, waking up for feeding is necessary for adequate nutrition and growth, and because the ability to retain energy has not developed yet. Newborn infants need milk 8 to 12 times a day, every 2 to 4 hours. By six months, the ability to retain energy has improved, allowing for longer periods of uninterrupted sleep. As a result, the number of nighttime feedings often reduces to twice or even fewer. (J. A. Mindell, Owens, and Carskadon 1999)

The differences between infants' and adults' sleep exist for a reason: primarily to support brain development. Over the first five years, sleep undergoes significant changes in all its dimensions, including duration, quality and architecture (Paavonen et al. 2020). In this article, we will detail some of these sleep changes and describe how they coincide with physiological processes essential for a child's growth and development.

Adult vs infant sleep structure

Sleep in adults and adolescents features a cyclic pattern, alternating between non-rapid eye movement (NREM) and rapid eye movement (REM). Each sleep cycle lasts 90–110 minutes. During the main sleep period, usually the nightly sleep, adults will go through 4–6 sleep cycles depending on the length of the period. (J. A. Mindell, Owens, and Carskadon 1999; Baranwal, Yu, and Siegel 2023)

The first 3 hours of sleep are dominated by NREM sleep. Adults and adolescents progress through three stages of NREM before entering into REM sleep. NREM sleep is the restorative phase with low brain activity. As mentioned, NREM is further classified into three subclasses: NREM1, NREM2 and NREM3.

The transition from wakefulness to sleep normally takes place via *NREM1*. This stage can include intense sleepiness, hypnagogic hallucinations, and muscle contractions, yet it usually lasts only a few minutes at a time. The EEG pattern changes from alpha waves to theta waves. True sleep begins when a person enters into *NREM2*, which is associated with decreased awareness of external stimuli and reduced muscle activity. Characteristic EEG markers of NREM2 are sleep spindles and K-complexes. Adults spend roughly 50% of their sleep in this stage, hence it

is also called ‘core sleep’. To contrast it to the deepest sleep stage, i.e. *NREM3*, it has also been referred to as ‘light sleep’ which is a somewhat misleading name. NREM2 sleep is essential for maintaining a healthy sleep cycle and supporting various cognitive and physical functions. *NREM3* makes an individual the least responsive to external stimuli. (J. A. Mindell, Owens, and Carskadon 1999; Baranwal, Yu, and Siegel 2023). Delta waves dominate in the EEG, breathing is regular and heart rate variability is synchronized to breathing. (Cabiddu et al. 2012; Baranwal, Yu, and Siegel 2023)

REM sleep occurs at the end of each sleep cycle. The first episodes of REM sleep are typically very short and the periods become longer as the night progresses. Subsequently, the easiest way to accumulate more REM sleep is to sleep longer in the morning. Most of the dreaming also occurs during REM sleep. The name for REM comes from the rapid eye movements associated with it. (J. A. Mindell, Owens, and Carskadon 1999; Baranwal, Yu, and Siegel 2023)

The infant sleep structure is very different from that of adults. The sleep cycles are much shorter, typically 50 to 60 minutes each. At the age of about 3 to 4 months, the sleep cycles gradually start to extend in duration. Each sleep cycle starts with *active sleep*, which is similar to REM sleep in many ways. After a period of *transitional sleep*, each sleep cycle typically ends with *quiet sleep*, which more closely corresponds to NREM sleep. Thus, the infant sleep cycle is almost completely reversed compared to that of an adult. (Bathory and Tomopoulos 2017; Barbeau and Weiss 2017)

During active sleep, the infant's brain activity increases and their eyes move rapidly under closed eyelids. In addition, their limbs may move and muscles may twitch. Breathing rate and heart rate can be irregular, and facial expressions may change. In contrast, during quiet sleep the infant is much more restful, and also the brain is less active. The third sleep stage, indeterminate or transitional sleep, shows components of both quiet and active sleep. Transitional sleep thus refers to the sleep phase between active sleep and quiet sleep. (Bathory and Tomopoulos 2017; Barbeau and Weiss 2017)

Adult vs infant sleep need

The need for sleep during the day decreases with age and also varies among individuals.

In order to perform optimally during the day, most adults need 7–9 hours of sleep each night. The American Academy of Sleep Medicine and the National Sleep Foundation recommend 7–9 hours of sleep per night for adults

and 7–8 hours for older adults. It is important to note that sleeping less or more than the recommended duration is often considered a sign of sleep or health issues. (Hirshkowitz, Whiton, Albert, Alessi, Bruni, DonCarlos, Hazen, Herman, Katz, et al. 2015; Hirshkowitz, Whiton, Albert, Alessi, Bruni, DonCarlos, Hazen, Herman, Adams Hillard, et al. 2015; Paruthi et al. 2016; Spruyt 2019)

Sleep specialist panels at the American Academy of Pediatrics and the National Sleep Foundation have issued recommendations for children's sleep durations. They recommend 14–17 hours for newborns, 12–15 hours for infants, 11–14 hours for toddlers, 10–13 hours for preschoolers, 9–11 hours for school-aged children, and 8–10 hours for teenagers. (Hirshkowitz, Whiton, Albert, Alessi, Bruni, DonCarlos, Hazen, Herman, Katz, et al. 2015; Hirshkowitz, Whiton, Albert, Alessi, Bruni, DonCarlos, Hazen, Herman, Adams Hillard, et al. 2015; Paruthi et al. 2016) A survey-based study on Finnish children supports these findings, with newborns and infants accruing 14–17 hours of sleep daily (Paavonen et al. 2020).

Adult vs infant sleep continuity and wake windows

Adults typically have only one sleep period daily. While brief awakenings at night are common for adults, they usually can self-soothe and fall back to sleep quickly. Overall, adults have longer and more consolidated periods of sleep compared to infants and young children. In contrast, young children's sleep is characterized by shorter sessions and frequent nocturnal awakenings.

The wake window is an important concept for understanding and managing an infant's sleep patterns. The wake window is the time span a person can remain comfortably awake between sleep periods. For infants, the wake window is the amount of time they can stay awake before they need another nap or sleep. The term is commonly used when discussing healthy sleep routines that are established according to the child’s age and developmental stage. The length of an infant's wake window gradually increases as they age and develop. Newborns have very short wake windows, while older infants can stay awake for longer periods (Jodi A. Mindell et al. 2016). It is vital to understand and adhere to an infant's suitable wake windows to support their ability to fall asleep and prevent sleep issues (Bathory and Tomopoulos 2017).

Sleep rhythm is the regular pattern of naps and nighttime sleep. Establishing a sleep rhythm helps infants adjust to a sleep routine that makes it easier for them to anticipate sleep times and fall asleep more easily. However, as wake

windows lengthen with age, the sleep rhythm must also evolve. For example, as an infant's wake window widens, the necessity for multiple daytime naps diminishes. In addition, the duration of nighttime sleep increases with age. (Galland et al. 2012; Jodi A. Mindell et al. 2016)

Newborns spend most of their day sleeping between feedings. By around 3 months of age, an infant's sleep pattern typically becomes more established and predictable. During this time, it is usual for the baby to develop a clearer sleep routine, which often includes taking three naps throughout the day. By 8 months, the sleep routine has further solidified, with most infants transitioning to just two daytime naps. By the age of 18 months, toddlers usually consolidate to a single daily nap on average. (Mindell et al. 2016)

However, infants' sleep patterns are highly individualized and can vary greatly. In addition, as an infant grows and their sleep and circadian rhythm develop, they go through transition periods during which the number of naps may decrease, or the timing and duration of sleep undergo changes. This process does not necessarily happen overnight but may take some time. Figure 1 provides an example of how an infant's sleep schedule may change from birth to one year.

Table 1. *Common wake windows, number of naps, and total daily sleep duration for infants at different developmental stages.*

Age [months]	Wake window	Number of naps	Total sleep time [h]
1	45–60 min	Several	15–20
2	60 min	3–5	15–17
3	60–90 min	3–5	15–17
4	1.25–2 h	3–4	14–15
5	2–2.5 h	3–4	14–15
6	2.5–4 h	2–3	14–15
7–11	3–5 h	2–3	13–15
12–18	3–6 h	1–2	13–14
18–24	4–6 h	1	13–14

Infant sleep physiology

Infant's circadian rhythm. The circadian system, the body's internal clock, regulates various functions, including hormonal control and sleep-wake patterns. For adults, the circadian system is essential, promoting high levels of daytime alertness and sustained sleep at night. Newborns lack a fully developed circadian rhythm at birth, with other biological needs more significantly influencing their sleep-wake patterns. (Hilliard 2006). Signs of developing circadian rhythms, however, are found in biological rhythms, e.g. in the rhythmicity of cortisol secretion or core temperature.

The infant's circadian rhythm continues to develop during the first months postnatally, increasingly influencing sleep regulation. (Joseph et al. 2015; Zornoza-Moreno et al. 2011)

The ability to self-soothe is crucial for initiating and maintaining sleep through arousals between sleep cycles. Self-soothing without parental assistance is a key component in achieving longer periods of sleep. However, it is not accurate to assume that the ability to sleep well inevitably improves with age. The calmness of sleep may temporarily decrease for example if an infant has learnt a new skill. (Ferber 2006)

Transition from wake to sleep. Consider the moment when an infant falls asleep. The state of alertness or arousal is controlled by a network of neurons between the brainstem and hypothalamus and cerebral cortex. Numerous neural pathways and neurotransmitter systems are active during wakefulness. (Blunden and Galland 2014; Saper 2006; Sheldon 2005) Sleeping, in contrast to wakefulness, involves deactivating these arousal pathways and activating those that promote sleep (España and Scammell 2011). Therefore, sleep and wakefulness are separate behavioral states that require relatively quick transitions from one to the other. Physiologically, the transitions happen by two mutually inhibiting feedback loops between sleep and wake control. (Saper 2006; Bathory and Tomopoulos 2017)

Somnogens, such as adenosine, are substances that promote sleep and accumulate in the body during wakefulness, thus aiding the onset of

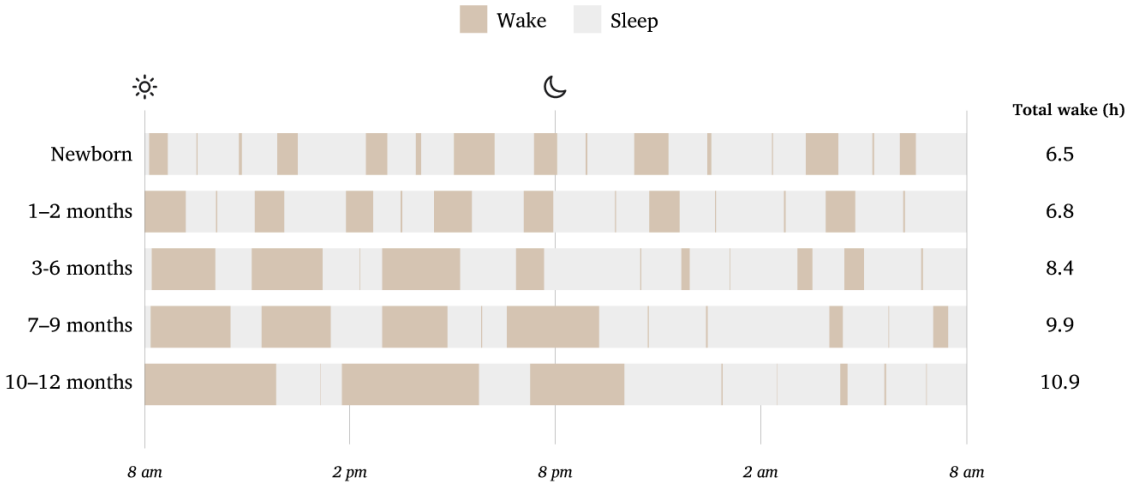

Figure 1. *A generalized depiction of an infant's main wake windows from newborn to one year, averaging out variations due to illness or transition periods.*

sleep (Basheer et al. 2004). Conversely, sleep reduces the concentration of somnogens in the body (Borbély and Achermann 1999).

Sleep continuity. Why don't infants sleep through the night? Infants are born with lower levels of melatonin, and their circadian rhythms, which regulate sleep, take time to mature. Over time, their bodies produce more melatonin, helping them establish longer nightly sleep and more regular sleep patterns in general. (Rivkees 2003). As discussed earlier, infants have a limited capacity for energy storage, which may make lighter sleep at night advantageous for them.

Science-backed tips for healthy sleep practices for families

It is important to support an infant's sleep to ensure they get enough rest. For example, fragmented sleep at night can reduce the total amount of sleep accrued over 24 hours because the infant may not compensate for the lost sleep during the day (Mäkelä et al. 2018). Infants often benefit from specific sleep environments to ensure their safety and comfort. There are some external cues that encourage or trigger an infant's transition from alertness to sleep. These external factors or actions support infants in falling asleep and maintaining healthy sleep patterns. Parents should consider these factors when managing their child's sleep rhythm:

- *Sense of security*: ensure a safe and secure environment for the infant.
- *Feeding*: a satisfied, full feeling aids in falling asleep.
- *Soothing actions*: gentle rocking or singing lullabies can be calming.
- *Consistent sleep routine:* establish and maintain a consistent sleep routine.
- *Comfortable sleep environment*: create a safe and restful sleeping area.
- *Reduced external stimuli*: minimize distractions.
- *Dimming lights*: lower lights before bedtime to signal that it is time to sleep.

Respond to the infant's needs while encouraging self-soothing appropriate for the infant's age and stage of development: techniques like swaddling, holding in side or stomach position, using white noise and swinging are recommended for supporting self-soothing. (Öztürk Dönmez and Bayik Temel 2019; Reuter et al. 2020; Sharman et al. 2023; Jodi A. Mindell et al. 2006)

Conclusion

The sleep-related scientific knowledge and tips provided in this article should be considered as general guidelines only. This is because each infant,

caregiver, and their life situation is unique. In practice, it may not be possible to directly apply these sleep-related recommendations; instead, it is important to adapt this information to find what works best for one's family situation.

As previously discussed at length, there are significant differences between adult and infant sleep. When a newborn joins the family, it is necessary to synchronize the sleep patterns of both the caregiver and the infant. Indeed, caring for an infant requires the caregiver to maintain a highly flexible schedule. The child's sleep largely determines the parent's sleep rhythm. Therefore, understanding and supporting an infant's sleep also supports the caregiver's sleep and their energy levels. This method is suggested to enhance positive parenting and improve responsiveness to the infant's needs (McQuillan et al. 2019).

References

Baranwal, Navya, Phoebe K. Yu, and Noah S. Siegel. 2023. "Sleep Physiology, Pathophysiology, and Sleep Hygiene." *Progress in Cardiovascular Diseases* 77 (February): 59–69.

Barbeau, Daphna Yasova, and Michael D. Weiss. 2017. "Sleep Disturbances in Newborns." *Children* 4 (10). https://doi.org/10.3390/children4100090.

Basheer, Radhika, Robert E. Strecker, Mahesh M. Thakkar, and Robert W. McCarley. 2004. "Adenosine and Sleep-Wake Regulation." *Progress in Neurobiology* 73 (6): 379–96.

Bathory, Eleanor, and Suzy Tomopoulos. 2017. "Sleep Regulation, Physiology and Development, Sleep Duration and Patterns, and Sleep Hygiene in Infants, Toddlers, and Preschool-Age Children." *Current Problems in Pediatric and Adolescent Health Care* 47 (2): 29–42.

Blunden, Sarah, and Barbara Galland. 2014. "The Complexities of Defining Optimal Sleep: Empirical and Theoretical Considerations with a Special Emphasis on Children." *Sleep Medicine Reviews* 18 (5): 371–78.

Borbély, A. A., and P. Achermann. 1999. "Sleep Homeostasis and Models of Sleep Regulation." *Journal of Biological Rhythms* 14 (6): 557–68.

Cabiddu, Ramona, Sergio Cerutti, Geoffrey Viardot, Sandra Werner, and Anna M. Bianchi. 2012. "Modulation of the Sympatho-Vagal Balance during Sleep: Frequency Domain Study of Heart Rate Variability and Respiration." *Frontiers in Physiology* 3 (March): 45.

España, Rodrigo A., and Thomas E. Scammell. 2011. "Sleep Neurobiology from a Clinical Perspective." *Sleep* 34 (7): 845–58.

Ferber, Richard. 2006. *Solve Your Child's Sleep Problems: New, Revised, and Expanded Edition*. Simon and Schuster.

Galland, Barbara C., Barry J. Taylor, Dawn E. Elder, and Peter Herbison. 2012. "Normal Sleep Patterns in Infants and Children: A Systematic Review of Observational Studies." *Sleep Medicine Reviews* 16 (3): 213–22.

Hilliard, T. 2006. "Principles and Practice of Pediatric Sleep Medicine." *Archives of Disease in Childhood* 91 (6): 546.

Hirshkowitz, Max, Kaitlyn Whiton, Steven M. Albert, Cathy Alessi, Oliviero Bruni, Lydia

DonCarlos, Nancy Hazen, John Herman, Eliot S. Katz, et al. 2015. "National Sleep Foundation's Sleep Time Duration Recommendations: Methodology and Results Summary." *Sleep Health* 1 (1): 40–43.

Hirshkowitz, Max, Kaitlyn Whiton, Steven M. Albert, Cathy Alessi, Oliviero Bruni, Lydia DonCarlos, Nancy Hazen, John Herman, Paula J. Adams Hillard, et al. 2015. "National Sleep Foundation's Updated Sleep Duration Recommendations: Final Report." *Sleep Health* 1 (4): 233–43.

Joseph, Desaline, Nelson W. Chong, Morag E. Shanks, Ezio Rosato, Nick A. Taub, Stewart A. Petersen, Michael E. Symonds, William P. Whitehouse, and Michael Wailoo. 2015. "Getting Rhythm: How Do Babies Do It?" *Archives of Disease in Childhood. Fetal and Neonatal Edition* 100 (1): F50–54.

Mäkelä, Tiina E., Mikko J. Peltola, Pirkko Nieminen, E. Juulia Paavonen, Outi Saarenpää-Heikkilä, Tiina Paunio, and Anneli Kylliäinen. 2018. "Night Awakening in Infancy: Developmental Stability and Longitudinal Associations with Psychomotor Development." *Developmental Psychology* 54 (7): 1208–18.

McQuillan, Maureen E., John E. Bates, Angela D. Staples, and Kirby Deater-Deckard. 2019. "Maternal Stress, Sleep, and Parenting." *Journal of Family Psychology: JFP: Journal of the Division of Family Psychology of the American Psychological Association* 33 (3): 349–59.

Mindell, J. A., J. A. Owens, and M. A. Carskadon. 1999. "Developmental Features of Sleep." *Child and Adolescent Psychiatric Clinics of North America* 8 (4): 695–725.

Mindell, Jodi A., Brett Kuhn, Daniel S. Lewin, Lisa J. Meltzer, Avi Sadeh, and American Academy of Sleep Medicine. 2006. "Behavioral Treatment of Bedtime Problems and Night Wakings in Infants and Young Children." *Sleep* 29 (10): 1263–76.

Mindell, Jodi A., Erin S. Leichman, Jordana Composto, Christina Lee, Bula Bhullar, and Russel M. Walters. 2016. "Development of Infant and Toddler Sleep Patterns: Real-World Data from a Mobile Application." *Journal of Sleep Research* 25 (5): 508–16.

Öztürk Dönmez, Renginar, and Ayla Bayik Temel. 2019. "Effect of Soothing Techniques on Infants' Self-Regulation Behaviors (sleeping, Crying, Feeding): A Randomized Controlled Study." *Japan Journal of Nursing Science: JJNS* 16 (4): 407–19.

Paavonen, E. Juulia, Outi Saarenpää-Heikkilä, Isabel Morales-Munoz, Minna Virta, Niina Häkälä, Pirjo Pölkki, Anneli Kylliäinen, Hasse Karlsson, Tiina Paunio, and Linnea Karlsson. 2020. "Normal Sleep Development in Infants: Findings from Two Large Birth Cohorts." *Sleep Medicine* 69 (May): 145–54.

Paruthi, Shalini, Lee J. Brooks, Carolyn D'Ambrosio, Wendy A. Hall, Suresh Kotagal, Robin M. Lloyd, Beth A. Malow, et al. 2016. "Recommended Amount of Sleep for Pediatric Populations: A Consensus Statement of the American Academy of Sleep Medicine." *Journal of Clinical Sleep Medicine: JCSM: Official Publication of the American Academy of Sleep Medicine* 12 (6): 785–86.

Reuter, Antonia, Sven-Arne Silfverdal, Kristin Lindblom, and Anders Hjern. 2020. "A Systematic Review of Prevention and Treatment of Infant Behavioural Sleep Problems." *Acta Paediatrica* 109 (9): 1717–32.

Rivkees, Scott A. 2003. "Developing Circadian Rhythmicity in Infants." *Pediatric Endocrinology*

Reviews: PER 1 (1): 38–45.

Saper, Clifford B. 2006. “Staying Awake for Dinner: Hypothalamic Integration of Sleep, Feeding, and Circadian Rhythms.” In *Progress in Brain Research*, edited by A. Kalsbeek, E. Fliers, M. A. Hofman, D. F. Swaab, E. J. W. van Someren, and R. M. Buijs, 153:243–52. Elsevier.

Sharman, Kirsten M., Kane Meissel, Josie E. Tait, Georgia Rudd, and Annette M. E. Henderson. 2023. “The Effects of Live Parental Infant-Directed Singing on Infants, Parents, and the Parent-Infant Dyad: A Systematic Review of the Literature.” *Infant Behavior & Development* 72 (August): 101859.

Sheldon, Stephen H. 2005. “Anatomy of Sleep.” In *Principles and Practice of Pediatric Sleep Medicine*, 35–41. Elsevier.

Spruyt, Karen. 2019. “A Review of Developmental Consequences of Poor Sleep in Childhood.” *Sleep Medicine* 60 (August): 3–12.

Zornoza-Moreno, Matilde, Silvia Fuentes-Hernández, Manuel Sánchez-Solis, María Ángeles Rol, Elvira Larqué, and Juan Antonio Madrid. 2011. “Assessment of Circadian Rhythms of Both Skin Temperature and Motor Activity in Infants during the First 6 Months of Life.” *Chronobiology International* 28 (4): 330–37.