



## Development of Sleep and Sleep Problems in Preterm Infants

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### **Topic**

*Sleeping behaviour*

### **Introduction**

Behaviour is the only way infants can communicate their needs to parents and other caregivers. Clinicians use changes in infant behaviours to alert them to possible medical complications that need further investigation,<sup>1</sup> and researchers use specific infant behaviours to identify pain<sup>2</sup> and responses to interventions that modify neonatal care.<sup>3</sup> Sleeping and waking not only affect the infant's immediate response to stimulation but, because they reflect the functioning of the central nervous system, have also been found to be related to developmental outcomes.<sup>4-8</sup>

### **Subject**

More than 12% of births in the U.S. are premature (less than 37 weeks of gestation). The sleep of premature infants differs from that of full-term infants. These differences may continue after the neonatal hospitalization.

### **Problem**

Sleeping and waking behaviours affect the development of preterm infants in multiple ways. First, sleeping and waking affect the infant's ability to respond to stimulation. Second, infants with neurological problems exhibit abnormal sleep patterns. Sleep and wakefulness may also have direct effects on brain development and learning that continue after the infant has been discharged home. Finally, differences in the sleep-wake patterns of preterm infants as compared to those of full-term infants might lead to sleep problems after hospital discharge.

### **Key Research Questions**

Research is needed to describe the development of sleep and waking in preterm infants and to examine factors in the hospital and home environment that affect this development, the relationship between sleep development in preterm infants and other areas of psychosocial development, and to determine the extent to which sleep of prematurely born children continues to differ from that of children born at term after infancy and the degree to which these differences are related to sleep problems.

### Research Context and Recent Research Results

A number of studies have shown that sleeping and waking affect preterm infants' response to stimulation. Preterm infants who were asleep showed less pronounced behavioural responses to painful procedures, such as heelsticks.<sup>9</sup> In the hospital, the preterm infant state changes frequently in response to nursing interventions or noise.<sup>10</sup> Preterms are rarely able to sustain quiet sleep during these interventions; they usually awaken.<sup>11</sup> In addition, sleeping position affects sleep patterns; preterm infants placed on their backs to sleep showed greater wakefulness, less quiet sleep, but fewer central apneas.<sup>12,13</sup>

Social interaction also affects and is affected by the sleep-wake patterns of preterm infants. Preterm infants exhibited less eye opening, and probably less waking, when interacting with their mothers than healthier preterms.<sup>14</sup> Mothers reported being aware of the sleep-wake behaviours of their preterm infants and using these behaviours when deciding to interact.<sup>15</sup> Healthier preterm infants opened their eyes more when with parents than when with nurses;<sup>16</sup> whereas sicker preterm infants spent more time in active sleep when with their parents.<sup>17</sup> Holding infants in skin-to-skin contact (kangaroo care) increased quiet sleep time as compared with periods when the infant was alone in the incubator.<sup>18,19</sup> Developmental care was associated with increased active and quiet sleep and decreased sleep latency,<sup>20</sup> and tactile stimulation was followed by greater amounts of sleep.<sup>21</sup> At four to six weeks (corrected age), breastfed premature infants cried more than formula-fed infants.<sup>22</sup>

Sleeping and waking reflect the underlying functioning of the brain.<sup>23,24</sup> The oscillations between sleep and waking originate in the brainstem, but their maintenance is due to interactions among neuronal populations that stretch from the brainstem to the cerebral cortex.<sup>25</sup> Sleep and wakefulness also have direct effects on brain development and learning. Because the nightly proportion of Rapid Eye Movement (REM) sleep is lower in adults than in infants, it has been hypothesized to be necessary for brain development.<sup>26</sup> This hypothesis has received some support from studies of full-term infants and animals.<sup>27,28</sup> Also, movements during active sleep – twitches, startles and rapid eye movements – may be needed for the development of neuromuscular and sensory systems.<sup>4</sup> The amount of active sleep is lower in the preterm neonates than in full-term newborns and increases with age in preterm infants.<sup>29,30</sup>

Because of the close relationship between the brain and sleep,<sup>4-6</sup> it is not surprising that sleep organization undergoes significant development in the preterm period. The amount of active sleep decreases and the amounts of quiet sleep and waking states increase over the preterm period.<sup>29-33</sup> The organization of sleep states, particularly the regularity of respiration in quiet sleep, the percent of active sleep with rapid eye movements, and the length of awakenings, also increases.<sup>4,29-32</sup> Boys show less active sleep, more drowsiness and more wakefulness than girls.<sup>33</sup>

Similar changes continue in the early weeks after term, although the rate of development slows somewhat.<sup>30,34,35</sup> At the same adjusted ages, preterm infants have less sleep, longer episodes of quiet sleep, more body movements, more frequent REM episodes, more

alertness and non-alert waking activity, and less drowsiness.<sup>34</sup> Preterm infants show day-night differentiation in sleep-wake patterns at similar ages or even earlier than fullterm infants.<sup>35</sup>

However, premature infants are more likely to have neurological insults. Preterm infants with neurological problems, such as intraventricular haemorrhage, have state patterns (less alertness, more active sleep and a narrower range of states) that differ from those of healthier infants.<sup>36,37</sup> Markedly abnormal neonatal electroencephalographic (EEG) patterns in infants with severe neurological problems are related to major neurological sequelae, such as epilepsy.<sup>38</sup> In addition, infants exposed prenatally to tobacco, alcohol or drugs exhibit abnormal state patterns, possibly as the result of neurological insults caused by the drugs.<sup>39-43</sup>

Consequently, sleeping and waking patterns of preterm infants have been associated with developmental outcomes.<sup>5</sup> Measures of sleep-wake states during the preterm period (the amount of crying, amount of rapid eye movements, quality of state organization, sleep cycle length and amount of night sleep) predict cognitive and motor development, as measured by the Bayley scores during the first year.<sup>5,8,44</sup> Developmental changes in the amounts of specific sleep behaviours during the first year are related to developmental outcomes in the second year.<sup>45</sup> Also, prematurely born children who showed a more rapid decrease in active sleep (more rapid development) in the preterm period averaged higher IQs and better language and fine motor abilities at three years than prematurely born children with slower active sleep development.<sup>6</sup> Further, the stability of sleep-wake patterns in the first month predicted later developmental handicap, including cognitive delays and seizures.<sup>46,47</sup> EEG sleep measures in preterm infants, even in the absence of specific neurological insults, have been related to risk for mortality and abnormal or suspect neurological outcomes.<sup>48</sup>

Although many parents and clinicians believe that children born prematurely are at risk for sleep problems, the literature does not support this belief, except for sleep-disordered breathing. Sleeping problems in the first six months are actually less common in preterm than fullterm infants.<sup>49</sup> At twenty months, preterm infants were found to have less restful sleep than fullterm infants.<sup>50</sup> Sleep patterns and incidence of sleep problems assessed through parental interviews from birth through ten years did not differ between children born prematurely and those born at term.<sup>51</sup> Prematurely born children from eight to eleven years of age with single mothers or exposed to mild pre-eclampsia had a greater risk of sleep-disordered breathing than other prematurely born children.<sup>52</sup> Young adults who were born prematurely did not differ from adults born at term in sleep quality or amount but were at greater risk for sleep-disordered breathing.<sup>53,54</sup>

## Conclusions

These findings indicate that sleep-wake patterns relate to the psychosocial development of preterm infants both directly, through effects on infant responsiveness and brain development, and indirectly, by influencing the types of social stimulation that preterm infants receive. Differences in the sleep-wake patterns of preterm infants as compared to full-term infants might lead to sleep problems after hospital discharge, but research to

date has not found an increased risk for sleep problems, except for sleep-disordered breathing. The most provocative findings suggest that sleeping and waking patterns could be used for examining brain functioning in relation to later development. However, to date the associations between preterm sleep patterns and later development have been too small for clinical use. Longitudinal indices of sleep behaviours might be more accurate since they avoid problems of temporary abnormalities in sleep-wake patterns due to immediate responses to the environment or medical complications. Also, these indices would make it possible to examine the degree to which the brain is able to exhibit normal development despite insults.<sup>27</sup> Future research needs to examine the development of sleep-wake organization in combination with factors in the social environment and to explore the sleep of prematurely born children after the first year of life.

### **Implications for Policy and Service Perspectives**

As intervention services are provided while infants are awake, service providers usually pay little attention to the sleep patterns of preterm infants, unless parents have complaints. However, research findings indicate that both sleeping and waking can have important effects on psychosocial development. Service providers need to be aware of how sleep-wake patterns are affecting the parent/preterm infant interactions and intervene as needed to promote more mutually satisfying interactions. Also, atypical sleep-wake patterns need investigation because they may be signs of underlying medical or neurological problems. Although parental concerns that prematurity causes sleep problems can be dispelled, sleep problems in prematurely born children should be treated in the same ways as sleep problems in children born at term.

On the other hand, research that uses sleep-wake states to predict long-term developmental outcomes is not yet ready for implementation in practice. However, it has potential to be used as an adjunct to other diagnostic criteria to help providers to better determine which preterm infants could benefit from early intervention and which infants will develop normally even without intervention.

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