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Development of Sleep and Sleep Problems in Preterm Infants

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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,[1] and researchers use specific infant behaviours to identify pain[2] and responses to interventions that modify neonatal care.[3] 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.[4-8]

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

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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.[9] In the hospital, the preterm infant state changes frequently in response to nursing interventions or noise.[10] Preterms are rarely able to sustain quiet sleep during these interventions; they usually awaken.[11] 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.[12,13]

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.[14] Mothers reported being aware of the sleep-wake behaviours of their preterm infants and using these behaviours when deciding to interact.[15] Healthier preterm infants opened their eyes more when with parents than when with nurses;[16] whereas sicker preterm infants spent more time in active sleep when with their parents.[17] 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.[18,19] Developmental care was associated with increased active and quiet sleep and decreased sleep latency,[20] and tactile stimulation was

followed by greater amounts of sleep.[21] At four to six weeks (corrected age), breastfed premature infants cried more than formula-fed infants.[22]

Sleeping and waking reflect the underlying functioning of the brain.[23,24] 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.[25] 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.[26] This hypothesis has received some support from studies of full-term infants and animals.[27,28] Also, movements during active sleep – twitches, startles and rapid eye movements – may be needed for the development of neuromuscular and sensory systems.[4] The amount of active sleep is lower in the preterm neonates than in full-term newborns and increases with age in preterm infants.[29,30]

Because of the close relationship between the brain and sleep,[4-6] 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.[29-33] 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.[4,29-32] Boys show less active sleep, more drowsiness and more wakefulness than girls.[33]

Similar changes continue in the early weeks after term, although the rate of development slows somewhat.[30,34,35] 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.[34] Preterm infants show day-night differentiation in sleep-wake patterns at similar ages or even earlier than fullterm infants.[35]

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.[36,37] Markedly abnormal neonatal electroencephalographic (EEG) patterns in infants with severe neurological problems are related to major neurological sequelae, such as epilepsy.[38] 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.[39-43]

Consequently, sleeping and waking patterns of preterm infants have been associated with developmental outcomes.[5] 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.[5,8,44] Developmental changes in the amounts of specific sleep behaviours during the first year are related to developmental outcomes in the second year.[45] 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.[6] Further, the stability of sleep-wake patterns in the first month predicted later developmental handicap, including cognitive delays and seizures.[46,47] 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.[48]

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.[49] At twenty months, preterm infants were found to have less restful sleep than fullterm infants.[50] 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.[51] 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.[52] 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.[53,54]

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.[27] 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.

References

1. Holditch-Davis D, Hudson DC. Using preterm infant behaviors to identify acute medical complications. In: Funk SG, Tornquist EM, Champagne MT, Wiese RA, eds. *Key aspects of caring for the acutely ill: Technological aspects, patient education, and quality of life*. New York, NY: Springer; 1995:95-120.
2. Evans JC, Vogelpohl DG, Bourguignon CM, Morcott CS. Pain behaviors in LBW infants accompany some “nonpainful” caregiving procedures. *Journal of Neonatal Nursing* 1997;16(3):33-40.
3. Chang YJ, Anderson GC, Lin CH. Effects of prone and supine positions on sleep state and stress responses in mechanically ventilated preterm infants during the first postnatal week. *Journal of Advanced Nursing* 2002;40(2):161-169.
4. Blumberg MS, Lucas DE. A developmental and component analysis of active sleep. *Developmental Psychobiology* 1996;29(1):1-22.

5. Ednick M, Cohen AP, McPhail GL, Beebe D, Simakajornboon N, Amin RS. A review of the effects of sleep during the first year of life on cognitive, psychomotor, and temperament development. *Sleep* 2009;32(11):1449-1458.
6. Holditch-Davis D, Belyea M, Edwards LJ. Prediction of 3-year developmental outcomes from sleep development over the preterm period. *Infant Behavior and Development* 2005;28(2):118-131.
7. Borghese IF, Minard KL, Thoman EB. Sleep rhythmicity in premature infants: implications for developmental status. *Sleep* 1995;18(7):523-530.
8. Gertner S, Greeenbaum CW, Sadeh A, Dolfin Z, Sirota L, Ben-Nun Y. Sleep-wake patterns in preterm infants and 6 month's home environment: implications for early cognitive development. *Early Human Development* 2002;68(2):93-102.
9. Johnston CC, Stevens BJ, Franck LS, Jack A, Stremler R, Platt R. Factors explaining lack of response to heel stick in preterm newborns. *Journal of Obstetric, Gynecologic and Neonatal Nursing* 1999;28(6):587-594.
10. Zahr LK, Balian S. Responses of premature infants to routine nursing interventions and noise in the NICU. *Nursing Research* 1995;44(3):179–185.
11. Brandon DH, Holditch-Davis D, Belyea M. Nursing care and the development of sleeping and waking behaviors in preterm infants. *Research in Nursing and Health* 1999;22(3):217-229.
12. Bhat RY, Hannam S, Pressler R, Rafferty GF, Peacock JL, Greenough A. Effect of prone and supine position on sleep, apneas, and arousal in preterm infants. *Pediatric*s 2006;118(1):101-107
13. Myers MM, Fifer WP, Schaeffer L, Sahni R, Ohira-Kist K, Stark RI, Schulze KF. Effects of sleeping position and time after feeding on the organization of sleep/wake states in prematurely born infants. *Sleep* 1998;21(4):343-349.
14. Minde K, Whitelaw A, Brown J, Fitzhardinge P. Effect of neonatal complications in premature infants on early parent–infant interactions. *Developmental Medicine and Child Neurology* 1983;25(6):763-777.
15. Oehler JM, Hannan T, Catlett A. Maternal views of preterm infants' responsiveness to social interaction. *Journal of Neonatal Nursing* 1993;12(6):67-74.
16. Minde K, Ford L, Celhoffer L, Boukydis C. Interactions of mothers and nurses with premature infants. *Canadian Medical Association Journal* 1975;113(8):741-745.
17. Miller DB, Holditch-Davis D. Interactions of parents and nurses with high-risk preterm infants. *Research in Nursing and Health* 1992;15(3):187-197.
18. Ferber SG, Makhoul IR. The effect of skin-to-skin contact (kangaroo care) shortly after birth on the neurobehavioral responses of the term newborn: A randomized, controlled trial. *Pediatrics* 2004;113(4):858-865.
19. Scher MS, Ludington-Hoe S, Kaffashi F, Johnson MW, Holditch-Davis D, Loparo KA. Neurophysiologic assessment of brain maturationafteran eight-week trial of skin-to-skin contact with preterm infants. *Clinical Neurophysiology* 2009;120(10):1812-1818.
20. Bertelle V, Mabin D, Adrien J, Sizun J. Sleep of preterm neonates under developmental care or regular environmental conditions. *Early Human Development* 2005;81(7):595-600.
21. Im H, Kim E. Effect of Yakson and Gentle Human Touch versus usual care on urine stress hormones and behaviors in preterm infants: A quasi-experimental study. *International Journal of Nursing Studies* 2009;46(4):450-458.
22. Thomas KA. Differential effects of breast- and formula-feeding on preterms' sleep-wake patterns. *Journal of Obstetric, Gynecologic, and Neonatal Nursing* 2000;29(2):145-152.
23. Halpern LF, MacLean WE, Baumeister AA. Infant sleep-wake characteristics: Relation to neurological status and the prediction of developmental outcome. *Developmental Review* 1995;15(3):255-291.
24. Thoman EB. A biological perspective and a behavioral model for assessment of premature infants. In: Bond LA, Joffee JM, eds. *Primary prevention of psychopathology.* Hanover, NH: University Press of New England; 1982:159-179. *Facilitating*

infant and early childhood development; vol 6.

25. Dahl RE. The regulation of sleep and arousal: Development and psychopathology. *Development and Psychopathology* 1996;8(1):3-27
26. Roffwarg HP, Muzio JN, Dement WC. Ontogenetic development of the human sleep-dream cycle. *Science* 1966;152(3722):604-619.
27. Denenberg VH, Thoman EB. Evidence for a functional role for active (REM) sleep in infancy. *Sleep* 1981;4(2):185-191.
28. Mirmiran M. The importance of fetal/neonatal REM sleep. *European Journal of Obstetrics Gynecology and Reproductive Biology* 1986;21(5-6):283-291.
29. Holditch-Davis D, Edwards LJ. Modeling development of sleep-wake behaviors: II. Results of 2 cohorts of preterms. *Physiology and Behavior* 1998;63(3):319-328.
30. Holditch-Davis D, Scher M, Schwartz T, Hudson–Barr D. Sleeping and waking state development in preterm infants. *Early Human Development* 2004;80(1):43-64.
31. Giganti F, Ficca G, Cioni G, Salzarulo P. Spontaneous awakenings in preterm and term infants assessed throughout 24-h video-recordings. *Early Human Development* 2006;82(7):435-440.
32. Scher MS, Johnson MW, Holditch-Davis D. Cyclicity of neonatal sleep behaviors at 25 to 30 weeks' postconceptional age. *Pediatric Research* 2005;57(6):879-882.
33. Foreman SW, Thomas KA, Blackburn ST. Individual and gender differences matter in preterm infant state development. *Journal of Obstetric, Gynecologic, and Neonatal Nursing* 2008;37(6):657-665.
34. Davis DH, Thoman EB. Behavioral states of premature infants: Implications for neural and behavioral development. *Developmental Psychobiology* 1987;20(1):25-38.
35. Whitney MP, Thoman EB. Sleep in premature and fullterm infants from 24-hour home recordings. *Infant Behavior and Development* 1994;17(3):223-234.
36. Doussard-Roosevelt J, Porges SW, McClenny BD. Behavioral sleep states in very low birth weight preterm neonates: relation to neonatal health and vagal maturation. *Journal of Pediatric Psychology* 1996;21(6):785-802.
37. Vohr BR, Karp D, O'Dea C, Darrow D, Coll CG, Lester BM, Brown L, Oh W, Cashore W. Behavioral changes correlated with brain-stem auditory evoked responses in term infants with moderate hyperbilirubinemia. *Journal of Pediatrics* 1990;117(2Pt1):288-291.
38. Scher MS. Neonatal encephalopathies as classified by EEG-sleep criteria: Severity and timing based on clinical/pathologic correlations. *Pediatric Neurology* 1994;11(3):189-200.
39. Black M, Schuler M, Nair P. Prenatal drug exposure: neurodevelopmental outcome and parenting environment. *Journal of Pediatric Psychology* 1993;18(5):605-620.
40. Huntington L, Hans SL, Zeskind PS. The relations among cry characteristics, demographic variables, and developmental test scores in infants prenatally exposed to methadone. *Infant Behavior and Development* 1990;13(4):533–538.
41. Nugent JK, Lester BM, Greene SM, Wieczorek-Deering D, O'Mahony P. The effects of maternal alcohol consumption and cigarette smoking during pregnancy on acoustic cry analysis. *Child Development* 1996;67(4):1806-1815.
42. Regalado MG, Schechtman VL, Del Angel AP, Bean XD. Sleep disorganization in cocaine-exposed neonates. *Infant Behavior and Development* 1995;18(3):319-327.
43. Stephan-Blanchard E, Telliez F, Léké A, Djeddi D, Bach V, Libert JP, Chardon K. The influence of in utero exposure to smoking on sleep patterns in preterm neonates. *Sleep* 2008;31(12):1683-1689.
44. Arditi-Babchuk H, Feldman R, Eidelman AI. Rapid eye movement (REM) in premature neonates and developmental outcome at 6 months. *Infant Behavior and Development* 2009;32(1):27-32.

45. Scher A. Infant sleep at 10 months of age as a window to cognitive development. *Early Human Development* 2005;81(3):289-292.

46. Thoman EB, Denenberg VH, Sieval J, Zeidner LP, Becker P. State organization in neonates: developmental inconsistency indicates risk for developmental dysfunction. *Neuropediatrics* 1981;12(1):45-54.

47. Tynan WD. Behavioral stability predicts morbidity and mortality in infants from a neonatal intensive care unit. *Infant Behavior and Development* 1986;9(1):71-79.

48. Hahn JS, Tharp BR. Winner of the Brazier Award. The dysmature EEG pattern in infants with bronchopulmonary dysplasia and its prognostic implications. *Electroencephalography and Clinical Neurophysiology* 1990;76(2):106-113.

49. Wolke D, Söhne B, Riegel K, Ohrt B, Osterlund K. An epidemiologic longitudinal study of sleeping problems and feeding experience of preterm and term children in southern Finland: comparison with a southern German population sample. *Journal of Pediatrics* 1998;133(2):224-231.

50. Gössel-Symank R, Grimmer I, Korte J, Siegmund R. Actigraphic monitoring of the activity-rest behavior of preterm and full-term infants at 20 months of age. *Chronobiology International* 2004;21(4-5):661-671.

51. Iglowstein I, Latal Hajnal B, Molinari L, Largo RH, Jenni OG. Sleep behaviour in preterm children from birth to age 10 years: A longitudinal study. *Acta Paediatrica* 2006;95(12):1691-1693.

52. Hibbs AM, Johnson NL, Rosen CL, Kirchner HL, Martin R, Storfer-Isser A, Redline S. Prenatal and neonatal risk factors for sleep disordered breathing in school-aged children born preterm. *Journal of Pediatrics* 2008;153(2):176-182.

53. Paavonen EJ. Strang-Karlsson S. Raikkonen K. Heinonen K, Pesonen AK, Hovi P, Andersson S, Jarvenpaa AL, Eriksson JG, Kajantie E. Very low birth weight increases risk for sleep-disordered breathing in young adulthood: the Helsinki Study of Very Low Birth Weight Adults. *Pediatrics* 2007;120(4):778-784.

54. Strang-Karlsson S, Raikkonen K, Kajantie E, Andersson S, Hovi P, Heinonen K, Pesonen AK, Jarvenpaa AL, Eriksson JG, Paavonen EJ. Sleep quality in young adults with very low birth weight~~:~~ the Helsinki study of very low birth weight adults. *Journal of Pediatric Psychology* 2008;33(4):387-395.