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BREAST-FEEDING AND MOTHER-INFANT COSLEEPING IN RELATION TO SIDS PREVENTION

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Though medical therapies (in most cases) are constructed from the data of biology, medicine in general pays little attention to what is probably the single most important concept in biology: the theory of evolution (Brown 1993: A3)

Sudden Infant Death Syndrome: The sudden death of any infant or young child which is unexpected by history and in which a thorough post-mortem examination fails to demonstrate an adequate cause of death. (Beckwith 1971).

Since being formally recognized as a medical entity in 1970, sudden infant death syndrome (SIDS, cot death, or crib death), a presumed sleep-related disorder primarily affecting infants in the first year of life (Fitzgerald 1995), has contributed to the deaths of well more than 290,000 babies in the Western world alone. Described as a "diagnosis by exclusion," the causes of SIDS still remain elusive; and, yet, for the first time in the history of SIDS research, death rates per 1000 live births are declining to unprecedented levels worldwide (Rognum 1995).

The breakthrough in reducing SIDS risks came from an unexpected direction—child care practices—specifically, the avoidance of the prone infant sleep position in favor of the side, supine, or back position. A warning about the dangers of prone sleeping was first published in 1944 by Abramson, who found that 68% of infants found dead in their cribs in New York City (55% of whom were under 5 months of age) were found lying face down. He recommended that: "the routine practice of placing infants in the prone position be

avoided except during such times as the babies are constantly attended. The practice should, furthermore, be entirely done away with at night" (1944:413).

Three years later Werne and Garrow (1947) echoed Abramson's research, arguing for the elimination of prone infant sleeping. It was not until 40 years later, however, following observations by Beal (1988), Beal and Bundell (1988) Davies (1985), de Jonge et al. (1989), Nelson (1989), and Tonkin (1986), that any attention was paid to the relatively high number of SIDS deaths associated with infants sleeping prone. National state-of the art epidemiological studies in Australia, New Zealand, and the United Kingdom were initiated, all of which confirmed that the prone infant sleeping position was, indeed, a significant risk factor for SIDS (see Fleming 1994; Guntheroth and Spiers 1992 for reviews). Between 1990 and 1992, following well-organized national campaigns recommending a change away from the prone infant sleep position to the supine (back) or side position, dramatic declines in SIDS were experienced in at least eight nations: Tasmania, New Zealand, the United Kingdom, Australia, Denmark, Norway, Sweden, and the Netherlands. Since 1992 in the United States, when the National Institutes of Health and the American Academy of Pediatrics initiated the "Back to Sleep" campaign, SIDS rates have fallen 30% nationally (Schaefer et al. 1996).

SIDS researchers are astonished that a behavioral child care practice over which parents assert control, rather than a surgical, pharmacological, or otherwise biological intervention, reduces SIDS rates so significantly. In fact, this discovery marked the beginning of an important paradigm shift toward associating suspected SIDS deficits with the infant sleep environment within which they occur (cf. Gantly et al. 1993; Einspieler et al. 1988; Johnson 1995). This discovery raised the possibility that other child care practices might also prove important.

Our research team studies child care practices in relation to SIDS prevention from the standpoint of the human infant's evolutionary legacy. For example, compared with other mammalian young, human infants are born neurologically much less mature, with only 25% of their adult brain volume (Konner 1981), and they exhibit a remarkably slow rate of biological and social maturation, during which time proximity and contact with the caregiver asserts a significant amount of external regulation of the infant's physiology, both day and night. Natural selection, we suggest, probably favored postnatal infant responsivity to parental sensory stimuli similar to the way it favored fetal regulation by the mother prenatally (McKenna and Mosko 1993), particularly during the 2- to 5-month period when infants are most susceptible to SIDS (Fleming 1994). Infants and mothers sleeping within arms reach (cosleeping) with nighttime breast-feeding represents the evolutionary stable sleeping arrangement and, indeed, the two practices (mother-infant cosleeping in tandem with breast-feeding) remain both inevitable and inseparable for most contemporary people (Konner 1981; Whiting 1981). We suggest, therefore, that not only are these two child care practices biologically appropriate, but that for the human infant, who develops extremely slowly and is born in such a helpless and dependent state, cosleeping may facilitate a unique

sensory bridge within the mother-infant dyad that maximizes the chances of optimal development and, in some circumstances, compensates for the infant's delayed maturity (McKenna 1986).

Historically, studies of pediatric sleep disorders and SIDS have universally failed to consider the potential benefits of breast-feeding and parental nighttime contact (cosleeping), probably because cultural values favor both early weaning and solitary sleep environments as a presumed strategy to produce independent children as early in life as possible (see Ferber 1985; Pinilla and Birch 1993; Spock and Rothenberg 1985). Moreover, Western scientists and SIDS researchers in particular are exposed to bed sharing (as representative of only one form of infant-parent cosleeping) mostly as it occurs under unsafe conditions as, for example, in urban and impoverished environments where infants are injured (or die from SIDS) while bed sharing sometimes at numbers approximately equal to (or higher than) the numbers of infants dying alone in cribs (Hauck 1997). Unsafe sleeping conditions such as an infant sleeping on the same surface next to a mother who smokes, or sleeping with an adult on a soft mattress (which is risky) come to be understood as an inevitable feature of all bed sharing and, thus, all bed sharing outcomes must be negative (Mitchell 1995). But just as solitary sleep environments for infants can vary from safe to risky, so can bed-sharing environments. That dangerous bed-sharing environments exist is no more of an argument against all bed sharing than the existence of unsafe cribs constitutes an argument against the safety of all solitary infant sleep.

The inference we draw from an evolutionary perspective is that, although mothers sleeping on a bed with an infant did not evolve per se, infants and mothers lying next to each other in some form or another for nighttime breast-feeding and nurturing did. We argue that unless infant sleep is recorded and measured within diverse cosleeping/breast-feeding contexts, "normal" species-wide infant sleep development in the first year of life will never be completely understood. More importantly, unless we know what constitutes biologically and socially "normal" infant sleep, we will be less likely to identify pathophysiologies that can conspire with environmental risk factors to increase SIDS risks (McKenna et al. 1990; Mosko et al. 1993). This is especially true where explanations for sleep-related disorders such as SIDS appear to be multifactorial and have multiple etiologies (Konner and Super 1987). It is possible, for example, that some of the babies that die from SIDS do so because solitary infant sleep may act to increase exogenous stressors, pushing some infants beyond their adaptive limits (McKenna et al. 1993).

Hypothesis

An evolutionary perspective on infancy predicts that infant-parent cosleeping with breast-feeding should be fitness enhancing for both the infant and parent; however, because there is no single cause of SIDS, no one prevention strategy, including cosleeping with breast-feeding or even the supine in-

fant sleep position, will necessarily eliminate SIDS, nor necessarily have a significant positive effect. In fact, because SIDS is relatively rare, there is no reason to suppose that cosleeping evolved specifically to prevent SIDS. Indeed, when practiced in combination with maternal smoking, soft-bedding, medicated or desensitized parents, or the prone infant sleep position, bed sharing is known to increase SIDS risks (Bass et al. 1986; Byard and Cohle 1994; Fleming 1996; Scragg et al. 1995; Wilson et al., 1994). It is, therefore, essential to acknowledge that dangerous sleeping conditions can transform an otherwise beneficial sleeping arrangement into a risky one (McKenna 1995).

With this caveat in mind, we hypothesize that, on the other hand, there may exist a subclass of SIDS-prone infants for whom the chances of succumbing to SIDS could be reduced in situations where mothers and infants remain close enough during sleep to monitor, exchange and/or respond to each other's sensory stimuli (e.g., movements, sounds, touches, smells, and exhaled gases). These sensory exchanges, we suggest, can change the infant's sleep and arousal patterns in potentially beneficial ways, while simultaneously increasing the chances of successful interventions by the caregiver should the infant experience a crisis during sleep. We do not suggest that solitary sleep causes SIDS per se, only that separation from the mother (or from some other primary caregiver) for extended sleep periods potentially enhances the deleterious effects of SIDS-related congenital deficits. This may be especially true for deficits that interfere with an infant's ability to arouse to reinitiate breathing following apnea, which can occur during deep stages of sleep when arousal threshold is high.

The background for our hypothesis emerges from four lines of evidence: (1) cross-cultural (ethnographic) data documenting the universal prevalence of infant–parent cosleeping and considerably reduced SIDS rates in cultures where, in the absence of maternal smoking, high maternal contact with cosleeping occurs (Barry and Paxton 1971; Davies 1985; Lee et al., 1989; Takeda 1987; Tasaki 1988; Whiting 1964, 1981); (2) cross-species laboratory studies of monkeys and apes showing the deleterious physiological consequences on infant monkeys following separation from their mothers for periods as short as 3–9 hours (see McKenna 1986 for a review); (3) human clinical studies showing the positive physiological effects of skin-to-skin contact ("kangaroo care") on preterm infants and neonates (Anderson 1991; Acolet et al. 1989; Field et al. 1986); and (4) SIDS research findings suggesting that increased breast-feeding frequency and duration (Fredrickson et al. 1993) and avoidance of the prone sleep (Guntheroth and Spiers 1992) can reduce SIDS risks and that some SIDS victims may have problems arousing from sleep before succumbing to SIDS (see Mosko et al. 1997a).

It should be noted that no controlled epidemiological studies have yet demonstrated a protective effect of cosleeping and that at least three major epidemiological studies show increased SIDS risk when mothers smoke, infants sleep prone, and/or mothers fail to breast-feed in the context of bed sharing. But where rates of maternal smoking are probably low and breast-feeding is high, SIDS rates are among the lowest in the world (Lee et al. 1989; Davies

1985; Takeda 1987; Tasaki 1988). That close contact with a parent during sleep contributes to these low SIDS rates is suggested by the recent increase in SIDS rates in Japan that has been paralleled by a shift from a tradition of mothers and infants sleeping together on futons to solitary sleeping in separate beds or futons (Wantanabe et al. 1994).

Observing Mother–Infant Cosleeping and Potential Adaptations in a Sleep Laboratory

Methods

Our studies of mothers and infants focus on bed sharing, which is only one of many different forms of mother–infant cosleeping. (Bed sharing occurs when a mother and infant sleep together on a raised mattress surface, often with a box spring underneath, all of which is ordinarily framed by both a head and foot board constituting a piece of furniture.) The research took place at the Sleep Disorders Laboratory, University of California, Irvine (UCI), under the direction of Sarah Mosko, a certified sleep specialist. We completed two small preliminary studies (McKenna et al. 1990; Mosko et al. 1993) and a larger study in which 35 healthy Latino mother–infant pairs (20 routine bed sharers and 15 routine solitary sleepers) spent 3 consecutive nights in our sleep laboratory (Mosko et al. 1997a, b, 1996; Richard et al. 1996). The methods and data described below are abbreviated and intended to provide an overview.

Subjects

The mothers in our study were Latina (mean 24.5 years of age, range 18–37) nonsmokers, had prenatal care, and delivered at UCI Medical Center, had no history of drug or alcohol use, and experienced uncomplicated pregnancies, labors, and deliveries. They were in good health, free of sleep disorders, and were taking no medications which could affect sleep patterns. Mothers had to meet our criteria for routinely cosleeping or routinely sleeping solitarily (see below) and have chosen their sleeping practice for reasons other than infant temperament. Mothers were all breast-feeding nearly exclusively, with little formula or food supplements, as determined from sleep and feeding logs kept daily by each potential recruit (see next section).

At the time of the study, infants averaged 12.6 weeks of age (range 11–16 weeks, the peak age for SIDS) and were in good health with normal growth and development as assessed by a pediatrician. At delivery all infants were >2500 in weight and >37 weeks gestation age with 5-minute Apgar scores of 8 or higher. All infants came from families with no history of SIDS in first-degree relatives, and none had experienced prolonged apneas or life-threatening events.

Identification of Routine Solitary and Routine Cosleeping Groups

Routine bed sharers (RB) were identified by cosleeping for at least 4 hours per night, 5 days per week; routine solitary sleepers (RS) shared beds no more than once per week for any part of the night. Mother–infant pairs were categorized into one of these groups (or excluded) based on daily sleep logs kept for 2 weeks that were completed at home before the sleep recordings to confirm maternal reports of the infant's usual home sleep environment. For the 33 pairs who completed 14 nights of the log, the mean number of bed-sharing nights was 13.7 for the RB group versus 0.6 for the RS group. All mothers were nearly exclusively breast-feeding (no more than 4 ounces of milk per any given day) as assessed from these same logs.

Procedures

Beginning with an "adaptation night" in the laboratory, mother–infant pairs slept as they routinely did at home. On one of the next 2 nights (the order being randomly chosen), the mother and infant slept again in the routine condition and the other night in the nonroutine condition. Continuous all-night polysomnographic and video recordings using infrared lamps were performed nightly. A single polygraph recorded all standard physiological parameters (EEG, EOG, EKG, air flow and respiratory effort, and oxygen saturation for the infants) simultaneously in the mother and infant. Axillary temperature and oxygen saturation were also recorded in the infants. All signals were written out simultaneously each night on a single 22-channel polygraph (Grass 8 plus).

Electrodes were attached first to the infant because they retire before mothers at home. Mothers positioned their infants for sleeping as usual each night with no instructions. Recordings begin when infants retired at their usual time. Mothers retired later, also at their normal bedtimes. They slept in rooms adjacent to their infants' rooms on solitary sleeping nights with the bedroom doors open so that they remained in auditory contact. Mothers responded to infant crying, etc., on an ad libitum basis, performing all caregiver interventions themselves each night.

Polygraphic recordings were scored for sleep stages in 30-second epochs according to accepted criteria. A widely used sleep scoring system for mothers was used which differentiates between brain, eye, and chin electrical signals needed to identify the sleep stages or awake periods, whereas the scoring system for 3-month olds, developed by Guilleminault and Souquet (1979), was used for the infants. Identification of sleep–wake stages in both scoring systems depends on three simultaneous parameters: EEG, EOG, and chin EMG. Five sleep stages are identified in adults: rapid eye movement (REM) stage plus four stages of non-REM sleep delineated as stages 1, 2, 3, and 4. In the infant, only three stages are defined: REM stage, stage 1–2, and stage 3–4. In the process of data reduction, stages 1 and 2 in the adult are combined to obtain a combination stage 1–2, and likewise stages 3 and 4 are combined for

comparability to infant sleep stages (because stages 1 and 2 and 3 and 4 are not easily distinguished for infants).

Sleep stage scoring was based on assigning to each 30-second epoch either wakefulness or one stage of sleep based on the predominant (greater than 50%) sleep or wakefulness pattern occupying the epoch. Although awakenings of 15 seconds or longer that meet these criteria (i.e., epochal awakenings) are automatically identified by this epochal system, shorter duration arousals occupying less than 50% of an epoch are not. Because of our interest in all arousal phenomena in sleep, however, we quantify these shorter arousals, calling them transient arousals, which were 3 seconds or more and were also identified by multiple signals, including EEG, following standard accepted criteria.

Infrared video recordings on all individuals across all nights were hand scored in real time in their entirety. Based on an ethogram of sleep-related behaviors, every observable behavior was recorded as it occurred, sequentially, and where appropriate its duration measured.

Selected Findings

Breast-feeding Patterns

Breast-feeding was defined as oral infant breast attachment and scored through observation of the video recordings combined with the sucking artifact (chin and tongue movement) on the polysomnograph (McKenna et al. 1997). Breast-feeding episodes began and ended with breast attachment and detachment, respectively, but also included very short interruptions of less than a minute during which the mother switched from one breast to the other. All breast-feeding episodes were elicited by the behavior of the infant but initiated by the mother placing her nipple in the infant's mouth and defined to capture a single intentional and continuous act of breast-feeding on her part. Thus, if breast-feeding was interrupted by maternal behaviors that indicated an apparent attempt to terminate feeding (e.g., by closing her bra or nightgown) but the infant's subsequent refusal to settle prompted the mother to reinitiate feeding, a new breast-feeding episode was scored. Three breast-feeding variables were computed each night: number, mean duration, and total duration, (sum) of breast-feeding episodes.

For the RB group, both the number and total duration of breast-feeding episodes were significantly higher on the bed-sharing night (BN) than on the solitary night (SN) (see McKenna et al. 1997 for details). The mean duration of breast-feeding episodes was also higher on the BN, but the difference just failed to reach statistical significance. Since no significant differences were found in either the infants' total time in bed or total sleep time on the two nights, the differences in breast-feeding could not be attributed to different-length sampling periods. The net result was that RB infants spent more than
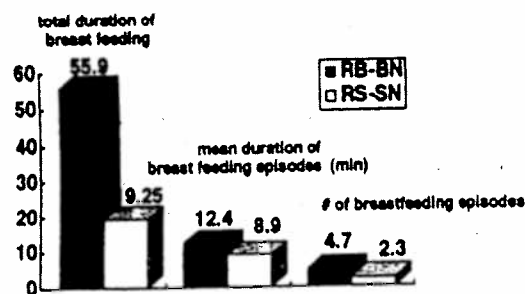
Figure 3.1. Number, mean duration (minutes per episode), and total nightly duration of breast-feeding episodes (minutes) among routinely bed-sharing (RB) and routinely solitarily sleeping (RS) mother–infant pairs on their bed-sharing night (BN) and solitary sleeping (SN) in a sleep laboratory (McKenna et al. 1997).

All three breast-feeding variables were also larger in the RS group on the BN than on the SN, but none of the differences reached significance. Similarly, comparing the two groups on the BN, the three breast-feeding variables were all larger in the RB group than in the RS group, but only the difference in total duration of breast-feeding episodes was significant (McKenna et al., 1997).

The largest differences found in breast-feeding were consistently between the two groups in their routine conditions (figure 3.1). Comparing the RB group on the BN to the RS group on the SN, the number of breast-feeding episodes was doubled, the total duration of breast-feeding episodes was nearly three times as great, and the mean duration of breast-feeding episodes was 39% larger in the RB group. A modestly longer total bed time in RB infants on the BN (544.2 ± 40.0 minutes) than for RS infants on the SN (512.7 ± 49.4 minutes) was insufficient to explain the large differences seen in breast-feeding.

Significance   Breast-feeding is known to reduce infant morbidity and mortality worldwide (Cunningham 1995; Cunningham et al. 1991; Jeliffe and Jeliffe 1978). These are the first data collected comparing breast-feeding in bed-sharing and solitary sleeping conditions, and the first data on nocturnal breast-feeding based on direct observation rather than on maternal recall, which has proven to be inaccurate (Quandt 1987; Vitzhum 1994a, b). The results are important because, although not all epidemiological studies suggest that breast-feeding lowers the risks of SIDS (see Gilbert et al. 1995), others do (Fredrickson et al. 1993; Hoffman et al. 1988; Mitchell et al. 1992), and many international SIDS prevention campaigns recommend breast-feeding as a way to help reduce SIDS risks. How breast-feeding protects some infants is not known, although the degree of protection offered by breast-feeding may be "dose dependent" (see Blackwell et al. 1993; Fredrickson et al. 1993; Jura et al. 1994); i.e., the more frequently infants are fed, the greater the protection.

The reduced average interval between feeds that accompanied the increased breast-feeding episodes on the bed-sharing night is extremely important in understanding how infants potentially regulate their mothers' ability to ovulate and, hence, to conceive. Mother–infant cosleeping, thus, reflects mutual regulatory processes. For example, reduced intervals between feeds are known to keep maternal prolactin levels high enough in the bloodstream to block ovulation (i.e., induce lactational amenorrhea), which potentially lengthens the birth interval. It is argued that the potential contraceptive effect of breast-feeding depends more on the structure of breast-feeding, including the daily intervals between feeds, rather than on simply breast-feeding or not breast-feeding (Ellison 1995; Knauer, 1985; Konner and Worthman 1980; McNeilly et al. 1994; Vitzhum 1989). The structure of nocturnal feeds we report here appears to maximize the chances of increasing the birth interval, thereby reducing the chances of exploiting (or exhausting) maternal resources, which theoretically can benefit both mother and infant.

Mother–Infant Interactions

Infrared videotape analysis revealed that, irrespective of the routine sleeping arrangement, during bed sharing all mothers were highly responsive to the emotional and physiological status of their infants. For example, all mothers exhibited behaviors during bed sharing that we have termed non-nursing maternal interventions that they rarely exhibited on the solitary night. These behaviors appear sometimes to be the result of something the infant needs or does; but often they involve affectionate kisses, hugs, or whispers that appear to be simply expressions of affection. We divide this behavioral category into two subdivisions: (1) protective behaviors involving the physical management and safety of the infant (e.g., blanket adjustments for thermal control, protecting the infants air passages, or repositioning the infant, visually inspecting the infant; and (2) affectional behaviors such as patting, kissing, whispering, speaking, singing, hugging, and rocking. Any of these behaviors can occur spontaneously without infant participation, but most occur in response to any audible or movement-related infant behaviors. In fact, in a subset of bed-sharing pairs that have been analyzed, of the 308 non-nursing maternal interventions observed on the BN, 87% of them were provoked by the infant, whereas 13% appeared to be spontaneously initiated by the mother. On average, and irrespective of routine sleeping behavior, mothers exhibited 6.8 (SD ±5.03) protective maternal interventions and an average of 8.1 (SD ±7.4) affectional interventions during the BN. There was little spontaneous checking up on the baby in the laboratory on solitary nights, except for breast-feeding episodes, which were elicited by the infant crying.

Significance   Maternal proximity during bed sharing appears to provide the infant with a range of both protective and affectional maternal behaviors simply not available in the solitary environment. Some of the advantages of maternal proximity are obvious, such as responding to an infant in physical distress or

preventing it from sleeping prone. Other benefits may be less obvious and may be in evidence at some point later in the child's life, given that some of the infant's nighttime emotional needs fulfilled by a bed-sharing mother may be quite subtle. Children from military families who cosleep appear to be under-represented in psychiatric populations and receive higher prosocial scores from their teachers than do children who do not cosleep (Forbes et al. 1992). Certainly, the functional significance of mother–infant nighttime behavioral interactions are complex, and they are likely to have both immediate and long-terms effects on the infant's social and psychological development, including the quality and strength of attachment to its caregiver and, possibly, the infant's reaction to stress later in life (Lewis and Haviland 1993). Although our study does not directly measure these outcomes, affectionate maternal interventions are known to significantly influence the direction of early emotional development to promote, for example, more empathy and social cooperation among children (see Lewis and Haviland 1993).

Bed-sharing Effects on Sleep Architecture and Arousals

An analysis of polysomnographic recordings scored for sleep stages and arousals revealed significant differences between the bed-sharing and solitary conditions in both infants and mothers (Mosko et al. 1996 1997a, b). All data were restricted to the time the mother was in bed each night. Repeated measures analysis of variance was used for the statistical analysis.

Infants On the BN, infants had longer total sleep time, more minutes and a greater percentage of stage 1–2, and fewer minutes and a lower percentage of stage 3–4 than on the SN, but REM stage was not affected. For the two stage 3–4 variables, there was a significant interaction effect, reflecting a larger night-effect in the RB group than in the RS group (figure 3.2). The BN was also associated with shorter mean duration episodes of uninterrupted stage 3–4 sleep but longer episodes of both stage 1–2 and REM stage irrespective of the infant's routine sleeping condition. In contrast, no significant differences were obtained for the longest duration or number of occurrences of any sleep stage. In addition, none of the sleep architecture variables were affected by the sex of the infant, as determined by covariant analysis (Mosko et al. 1996).

Bed sharing was also found to promote infant arousals (Mosko et al., 1997b). Stage comparisons revealed that stage 3–4 sleep is associated with a striking paucity of rousals, compared to the other sleep stages. Bed sharing facilitated both transient arousals and the more sustained epochal awakenings *selectively* in stage 3–4 sleep. Epochal awakenings from stage 3–4 were more frequent on the BN than on the SN in both infant groups. Furthermore, RB infants exhibited more frequent transient arousals in stage 3–4 than RS infants in both sleeping conditions. Arousals from sleep are potentially very important in that observations in victims of SIDS support a role of arousal deficiency in the etiology of SIDS (see Mosko et al., 1997 a, b). The greatest effect of bed
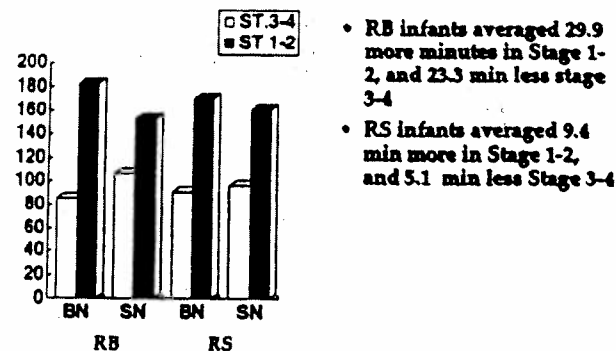

Figure 3.2. Comparison on infant sleep architecture in routinely bedsharing and routinely solitary sleeping infants on the bedsharing (BN) and solitary (SN) nights (Mosko et al., 1996).

sharing on infant arousals concerned temporal overlap with maternal arousals: the number of overlapping arousals doubled on the BN in both RB and RS infants (figure 3.3). The greatest differences were in those where the infant aroused first. All within- and between-group comparisons of the BN and SN resulted in significant differences for all three types of arousals: those where the mother aroused first, those where the infant aroused first, and those where arousals appeared simultaneous (Mosko et al. 1997b).

Mothers On the BN, mothers of both groups had slightly less stage 3–4 sleep (minutes and percentage) and more stage 1–2, with no change in REM (rapid eye movement) or total sleep time. As in infants, the decrease in stage 3–4 on the BN was due to a significant decrease in the mean duration of stage 3–4 episodes rather than in the number of occurrences of stage 3–4. Contrary to popular expectations, bed sharing did not result in shorter maternal sleep, despite the fact that there was a uniform effect on arousals in that the frequencies of total arousals were more in both groups of mothers while bed sharing (Mosko et al. 1996 Mosko et. al 1997b). Moreover, all significant interaction effects in mothers reflected enhancement of the effects on sleep and arousal variables in the RB compared to the RS group (Mosko et al. 1997a, b). This indicates that, rather than habituation to the baby's presence, there was evidence of increased sensitization by the RB mothers to the effects of the baby's presence.

The increase on the BN in overlapping arousals was even greater in the mothers than in the infants, with an approximate threefold increase. By far the largest magnitude increase was in the number of arousals where the infant aroused first, although all group comparisons (within or between groups) of the BN and SN revealed significant differences for all three types of arousals (Mosko et al. 1997a).
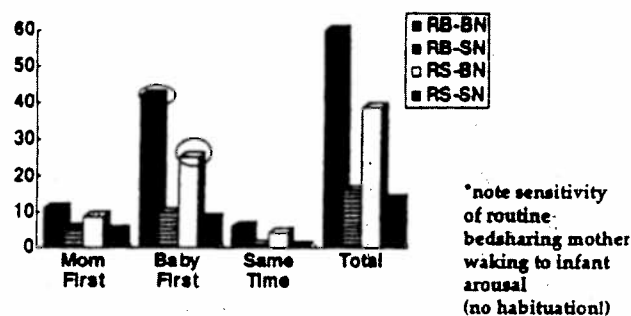
Figure 3.3 Mean number of infant arousals overlapping maternal arousals when the mother aroused first, or the baby aroused first, or they aroused simultaneously (from Mosko et al. 1997b).

Significance   The findings of an increase in infant arousals and a decrease in stage 3–4 sleep in the bed-sharing versus solitary condition are important when considered in the context of the hypothesis proposed by several researchers that SIDS is attributable at least in part to a defect in arousal mechanisms. If the arousal-deficiency hypothesis is correct, then factors that facilitate arousals or arousability might act to minimize the risk for SIDS in vulnerable infants. Stage 3–4 sleep is associated with a high arousal threshold; limiting the total amount and duration of episodes of this stage by bed sharing might increase the likelihood that an infant would be able to arouse if faced with a prolonged apnea or other potentially life-threatening event in sleep (Mosko et al., 1996). The increase in infant arousals that occurs with bed sharing might also promote arousability by ensuring a basal level of practice in arousing, practice which might be critical to infants deficient in intrinsic arousal mechanisms (Mosko et al. 1996, 1997a). The temporal overlap with maternal arousals is important to the arousal hypothesis because the overlap suggests that many arousals are occurring at times they otherwise would not have; the occurrence of these apparently nonspontaneous arousals is evidenced by those instances where the mother arouses first or the arousals appear simultaneous (Mosko et al. 1996, 1997a & b). The presence of all these effects of bedsharing in the RB infant group suggests that the effects are not due to the novelty of bedsharing and, furthermore, that the effects do not habituate (Mosko et al. 1996).

That the percentage of stage 3–4 is only mildly reduced in mothers while bed sharing, plus the facts that the mothers' total sleep time was not reduced by bed sharing and that both RB and RS mothers rated their sleep on the BN as satisfactory and representative of their usual sleep at home, act to dispel a popular notion that bed sharing is unacceptably disruptive to a parent's sleep (Mosko et al. 1997b in press). Finally, bed-sharing factors that enhance a parent's arousability (less stage 3–4 sleep and more frequent arousals) would be

expected to be protective to infants because the parent would be more likely to detect and, hence, reverse any potentially dangerous condition developing in the infant (such as a prolonged breathing pause, apnea, or choking). That all of the effects of bed sharing on maternal sleep and arousals were measured in both RB and RS mothers suggests they are not novelty effects and do not habituate. Furthermore, that the increase in total arousals on the BN was significantly larger in the RB mothers suggests that this effect of bed sharing is actually enhanced by routine bed sharing (Mosko et al. 1996, 1997a, b).

Body Positions in Bed

Prone infant sleeping position is the most recently identified risk factor for SIDS, carrying a relative risk of 8.8 (Fleming 1994). Although the mechanisms for this increased susceptibility remain unknown, some investigators have proposed that hyperthermia (Fleming et al. 1990; Nelson 1989) or hypercapnia (excessive CO_2) (Chiodini and Thach, 1993) are involved. Our analysis of infant sleeping position arose from an observation that bed-sharing infants are almost always placed on their backs, in the safer supine position (which appears to facilitate easier breast-feeding), while solitary sleeping infants were more often placed prone for sleep. Mothers in our study were always allowed to place their infants in bed without instruction to best replicate their behavior at home. In addition, our preliminary experiments on infant exposure to maternal CO_2 indicated that the orientation and proximity of an infant to the mother is a critical factor in the level of CO_2 exposure. This led us to measure the amount of time bed-sharing mother–infant pairs spent facing each other (Mosko et al. 1995).

Data presented here were derived from videotape recordings of the first six RB pairs and six RS pairs on both their solitary and bed-sharing nights. A clock in the field of view was used to partition the entire night into four position categories (prone, supine, left side, and right side) on a minute-by-minute basis. The same data were then recategorized to measure the amount of time that each member of the pair faced toward or away from the other member. Movement time (e.g., body position changes or feedings) was excluded from the analyses. The proximity of the mother's face to the baby's face was computed by measuring the distance on the video screen and converting it to actual distance by comparison to an object of known length placed in the field of view (see also Mosko et al. 1997b).

The most striking result was that both RB and RS infants were never placed prone while bed sharing (figure 3.4). Some infants (three RB and one RS) were placed prone on the SN and one additional RS infant was placed prone on the BN, but only until the mother got into bed. In most cases, the infant spent most of his or her time in just one of the position categories; i.e., most infants were repositioned once or not at all after going to bed and all but one were unable to reposition themselves. Due to this infrequent nature of infant position changes, many of the values in the analysis were zero. Therefore, variability

was very high and statistical tests indicated no significant differences between positions. The most common infant sleeping position on the SN was supine, but on the BN infants showed a wider range of positions (excluding prone). No clear differences exist between RB and RS infants. Note that in our continuing analyses of the remaining pairs, we have documented two cases where infants were placed prone for bed sharing. However, the data continue to support a strong preference for the nonprone positioning (Richard et al. 1996).

Analyses of the number of minutes spent facing the sleeping partner during bed sharing clearly show that, irrespective of routine condition, both members of a pair orient toward the other member (figure 3.5). This behavior is most evident for the infants; our analysis demonstrated that the infants spent significantly more time facing their mothers than facing away, regardless of routine sleeping condition. Mothers also spent significantly more time facing the infant than not. More than half of the infants (7/12) faced the mothers 100% of the night. Only two infants spent less than 40% of the night oriented away from the mother (range 23–100%). Almost all mothers were oriented toward their infants for most of the night (range 37–98%). The difference between the time that either member spent facing the other and the time facing away was more pronounced for the RB pairs than the RS pairs. The ratio between the time mothers faced toward the infants and the time they faced away was about 3:1 for the RB mothers versus 1.25:1 for the RS mothers; similarly, that ratio for the infants was about 7:1 for the RB infants versus 4:1 for the RS infants. The average RB pairs spent about twice as much time facing each other as did RS pairs (Richard et al. 1996).

Significance   As reported elsewhere (Richard et al. 1996), these data suggest that bed sharing fosters face-to-face orientation in both RB and RS pairs, an effect which is further enhanced in mothers that routinely bed share. This orientation may be the reason for the minimization of the prone position in bed-
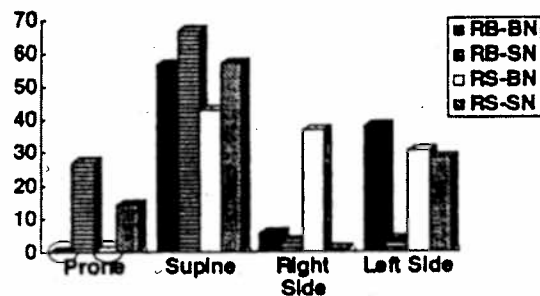

Figure 3.4 Percentage of nights routinely bed-sharing (RB) and routinely solitarily sleeping (RS) infants slept prone, supine, or on the right or left side (as positioned by their mothers) on the bed-sharing night (BN) and solitary nights (SN) in the laboratory (from Richard et al. 1996).
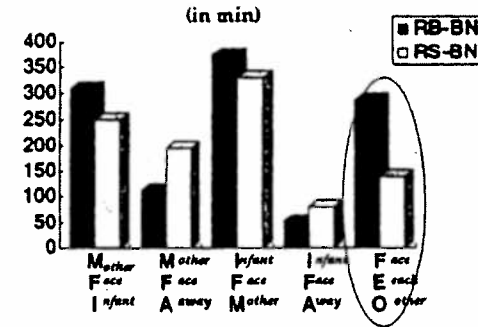
Figure 3.5 Number of minutes in which routinely bed-sharing (RB) mother–infant pairs and routinely solitarily sleeping (RS) mother–infant pairs faced each other and/or away (either partner) on the bed-sharing night (BN) in the sleep laboratory (from Richard et al. 1996). Note: routinely bedsharing mother/infant dyads, on their routine bedsharing night, face each for almost twice the amount of time per night than do routinely solitary sleeping mother/baby pairs on the bedsharing night; this suggests a kind of sensory bridge develops while bedsharing, which is not apparent when bedsharing is not routinely practiced.

sharing infants, but, whatever the reason, the bed-sharing environment seems to greatly diminish prone sleeping, which is important in terms of SIDS prevention. All of the infants in this study were placed in bed by the mother, which might preclude one from calling this infant "behavior"; however, infants that slept supine spent most of the night facing toward the mother, indicating that they, too, orient toward the mother. These behaviors during bed sharing have several implications; for example, they refute the idea that bed sharing imposes a substantial risk of overlying because the mother's preferred orientation toward the infant suggests she is highly cognizant of the infant's presence (Richard et al. 1996; Mosko et al. 1997a, b).

Summary

Our findings reveal that routinely bed-sharing infants breast-feed twice as frequently, which reduces the average interval between breast-feeding episodes. Moreover, infants breast-feed for almost three times the total nightly duration as do solitarily sleeping infants. Bed-sharing mothers almost always place their infants in the safer supine infant sleep position rather than in the more risky prone position, probably to facilitate side-by-side breast-feeding. Infants and mothers face in the direction of each other for much of the night. Mothers and infants exhibit more arousals and arousal overlaps while bed sharing and, by reducing the amount of time both mothers and infants spend in deeper stages of sleep (stage 3–4) and increasing the amount of time spent in stage 1–2, cosleepers assert an important regulatory effect on each other's sleep architec-

ture. Contrary to the popular stereotype about how bed sharing disturbs or shortens the one's sleep, routinely bed-sharing mothers and infants slept as much on their routine bed-sharing night as did routinely solitary-sleeping mothers and infants under their customary condition. Behavioral analysis also reveals that mothers are highly sensitive to their infants' behaviors while bed sharing, exhibiting a high number of protective and affectionate responses toward them throughout the night, responses that were not exhibited when they slept in different rooms.

The data we present cannot provide direct support of our hypothesis that cosleeping might protect some infants from SIDS, but they do provide important insights into the ways infant and maternal behavior and physiology are entwined in adaptive or potentially adaptive ways. For example, if breast-feeding offers "dose-dependent" protection against SIDS as Fredrickson et al's (1993) data suggest, then by increasing both the frequency and total nightly duration of breast-feeding, bed sharing may enhance the protective effect. If the supine infant sleep position is safer than the prone position, then by placing their infants supine for sleep, bed-sharing mothers reduce risks incurred by prone sleeping. If some SIDS-prone infants exhibit arousal deficiencies, then bed-sharing might provide the infant with valuable opportunities to practice arousing (in response to the mothers' arousals), thereby developing abilities potentially applicable during life-threatening apneas. If some SIDS-prone infants have difficulties arousing to reinitiate breathing from deep stages of sleep (following apneas), when arousal thresholds are high, then bed sharing might alleviate this potential vulnerability by reducing the total time and average episode length of stage 3–4 sleep. And, finally, if maternal interventions such as touch or movement can induce arousals or stimulate infant breathing, then a mother's proximity to her infant in the bed-sharing context, and her increased time spent in lighter stages of sleep, increase the chances of her successfully detecting and responding quickly to acute infant distress.

Beyond SIDS: The Evolutionary Ecology of Infant Sleep

Sleep medicine informed by models of human infant evolution may potentially produce new and exciting interpretations and potential solutions to several contemporary pediatric sleep disorders. For example, it may be a small but nonetheless important consolation for the estimated 20–40% of parents struggling with questions concerning why their infants or children will not sleep alone to know that, from a biological perspective, such struggles are predicable (if not appropriate). These behaviors and the infant behaviors that underlie them evolved in attempts to ameliorate what surely amounted to a life-threatening situation (i.e., separation from mother). Indeed, we can speculate that natural selection probably favored infants and children who, upon finding themselves separated from their caregivers, protested (by crying). Infants crying during the night to elicit parental contact, perhaps had better chances of survival than did offspring who failed to protest, if indeed parents

and infants were ever separated at night before recent times. What typically in Western culture is considered to be an infant "sleep problem" or "disorder" may instead represent an ancient emotional response (however out of synch with present cultural habits) reflecting a highly vigorous, well-adapted infant or child who needs parental contact to feel satisfied or protected. From this evolutionary perspective, it would be the infant or child who passively accepts the absence of the parent on whom its survival depends, and fails to protest that behaves biologically inappropriately, not the other way around. Which perspective one adopts (an evolutionary or a cultural one) determines how the behavior is to be interpreted: from a biological perspective, infants protesting sleep isolation from their parents (by crying) must be regarded as adaptive, whereas from the the perspective of a Western, urban parent, the behavior could be interpreted as a deficiency in the parent, the infant, or both.

The developmental significance placed on the ability of infants to "sleep through the night" at 2–4 months of age (see Ferber 1985) is, yet, another Western cultural construct having little to do with what an infant's biology is designed to experience (see Elias et al. 1986, 1987, Konner 1981; McKenna 1986). Breast-feeding and cosleeping practically guarantees, as our data show, that infants do not sleep without awakening briefly or arousing frequently throughout the night, specifically in relationship to mother's presence and/or activities, but also in response to its own internal needs. Yet, the expectation and perception of infant sleep consolidation and self-soothing back to sleep without parental intervention remains a widely accepted benchmark against which infant's developmental "progress" or maturity in Western cultures is measured and evaluated. This reflects the fact that an infant's ability to sleep alone and continuously without either feedings or parental contact is a *cultural* goal based on Western cultural judgments (see Pinilla and Birch 1993). It does not necessarily reflect the biological goals or needs of the human infant who, by awakening, regulates its oxygen supply, hunger, or communicates its need to be handled and reassured by the caregiver (Elias et al. 1987; McKenna et al. 1997a & b). It may be encouraging for parents to know that the real causes of infant– or child–parent sleep struggles are not necessarily deficient parenting skills or spoiled infants or children. Historically recent cultural ideologies and expectations about how infants *should* sleep, rather than how they were designed by evolution to want to sleep could be undermining physical and psychological health.

Pediatric Sleep Medicine: "Back to the Future"?

Child care practices change much faster than infant biology, and the majority of research on human infant development suggests strongly that it is far more likely to find negative socioemotional and physiological consequences when contact between parents and children is reduced rather than increased, irrespective of time of day (see McKenna and Mosko 1991; Lewis and Haviland 1993). Indeed, except where benefits are defined in terms of parental interests

or other cultural values, or where bed sharing occurs under unsafe conditions, there is not one scientific study documenting the presumed socioemotional, psychological, or physiological benefits of solitary infant sleep or the presumed deleterious consequences of infant–parent cosleeping.

Isolated infant sleep is a recent cultural innovation, no more than a few 100 years old, affecting only a relatively small number of infants worldwide (Barry and Paxson 1971; McKenna 1986; Whiting 1964). Such a biologically novel sleeping arrangement, we speculate, places infants at odds with their innate need to feel protected and close to their caregivers for feeding and nurturing. It also deprives the infant of an "expected" source of constant sensory exchange with its mother's body, with which it is designed to be in constant physiological transaction.

The concept of evolution and human evolutionary data offer physicians, biomedical researchers, and parents a powerful, unbiased point to begin to understand and reconceptualize infant sleep and sleep-related disorders, only one of which is SIDS. While pediatric medical problems framed by evolutionary theory cannot guarantee solutions, it is clear that infant sleep research is enriched and made more accurate by recognizing at the outset the essential and irrefutable biological complimentarity between *evolved* infant needs (nutritional, emotional, social, and transportational) and intense parental contact both day and night.

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