

**EFFECTS OF FEEDING METHOD ON
INFANT SLEEP CONSOLIDATION
ACROSS 12 MONTHS**

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Abbreviations

Brf: Breastfed

nBrf: Bottle or mixed method of feeding

BFI: Breast-feeding Index

CSS: Composite Sleep Scores

LSRSP: Longest Self-Regulated Sleep Period

SCI: Sleep Consolidation Index for uninterrupted sleep

SCI-5: Sleep Consolidation Index midnight – 5:00 am

SCI-8: Sleep Consolidation Index eight hours of uninterrupted sleep

SCI-F: Sleep Consolidation Index 10:00 pm – 6:00 am

TLVR: Time-Lapse Video Recording

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Abstract

The aims of this research were to examine the effects of infant feeding method on sleep development across the first twelve months of life, and to determine whether there are differences in sleep development between infants who are exclusively breastfed and those who are not. The participants were 52 infants and their parents. Parents completed sleep diaries for six consecutive nights once a month, for 12 months starting at one month of age, recording infant and parent sleep-related behaviours. It was predicted that infants who were breastfed for a longer period would have higher instances of night waking, would take longer to achieve the three criteria for sleeping through the night, and would have higher Composite Sleep Scores (Richman, 1981) than their non-breastfed counterparts. There was an unexpected high rate of breastfeeding in the sample of infants across the first 12 months. The breastfed infants displayed less night waking than their mixed or bottle-fed counterparts before three months of age, but more night waking after three months for the remainder of the study. They also took longer to reach each of the three sleeping through the night criteria. However, two subsets appeared within the breastfeeding group - those infants who experienced consolidated sleep earlier than six months of age, and those who did not. This finding demonstrated that breastfed infants are capable of sleeping through the night from an early age, contrary to what previous literature suggests.

Effects of Feeding Method on Infant Sleep Consolidation

Critical features in the life of the newborn are eating and sleeping, and these are of major interest and concern to parents. This thesis is concerned with the relationship between these activities, and more specifically: does infant feeding experience influence sleep development? Research has shown that a newborn infant can sleep for approximately 16 hours a day (Wolfson, Lacks, & Futterman, 1992; Hiscock, 2008), and the full adult pattern of sleep is not typically attained until late adolescence. This slow development of adult sleep notwithstanding, infant sleep development does proceed rapidly over the first year of life. Young neonates experience on average four hours of uninterrupted sleep per sleep episode, which increases for the majority of infants to 10 - 12 hours during the nocturnal period by the end of the first year (Henderson, France, Owens & Blampied, 2010). The development of this pattern of consolidated sleep is influenced by the interaction of bio-psychosocial factors on several levels, and determines whether an infant will develop sleep self-regulation or not by the end of their first year. Sleep is important for infants as it supports cognitive development, mood regulation, attention, behaviour, and overall health (Mindell, Kuhn, Lewin, Meltzer, & Sadeh, 2006). If the developing infant is not achieving sufficient good-quality sleep, infants will most likely be negatively affected in these domains when compared with their peers who are sleeping well. The duration and quality of their infant's sleep is also of great and continuing interest to parents and other family members as it may impact on their health and wellbeing both as individuals and as a family.

Parent behaviours occurring in the context of the sleep setting are reported in the literature as having the strongest associations on later sleep outcome (Tikotzky & Sadeh, 2009). Feeding an infant is one parental behaviour that is necessary to provide

the infant's nutritional requirements necessary for growth and survival. Since babies can feed only when awake, the feeding schedule necessarily interacts with its sleep schedule. Furthermore, in evolutionary terms, there was only one way an infant could be fed, namely by breast feeding, but human technological development has made it increasingly possible to meet infants' nutritional needs by artificial feeding, namely bottle feeding. It is possible that both the feeding schedule and feeding method may interact with sleep development to either facilitate or impair the infant's ability to learn self-soothing skills and achieve sleep consolidation. Given the vital nature of feeding and sleep, understanding any such interactions is of critical importance. As noted, common feeding methods for young healthy developing infants include exclusive breast-feeding, exclusive bottle-feeding or a combination of both methods.

The benefits of breastfeeding infants are empirically well established, including the reduced likelihood of respiratory tract infections and other illnesses, as well as long-term effects such as reduced rates of Sudden Infant Death Syndrome (SIDS) and Type 2 diabetes (Godfrey & Meyer, 2009; Horta, Bahl, Martines, & Victor, 2007; Galbally, Lewis, McEgan, Scalzo, & Islam, 2013). However, the normal and natural act of breastfeeding and its influence on sleep development has been the subject of rigorous academic debate in the literature (Gettler & McKenna, 2011; McKenna & McDade, 2005). Investigations assessing the role of breastfeeding and other feeding methods, and sleep developmental outcomes remain inconclusive and the influence of feeding on sleep remains largely unknown.

The sleep patterns of young neonates is characterised by a multi-phasic cycle of short periods awake and asleep, interspersed by feeding, general care, and nurturing. There is a gradual developmental shift from a multi-phasic sleep wake schedule to a more sustained diurnal sleeping pattern, which occurs in synchrony with

other important developments (Blampied & Bootzin, 2013). The debate in the literature centres on the question of whether helping infants achieve a duration of uninterrupted sleep often referred to as “sleeping through the night” should be encouraged if it comes potentially at the expense of breastfeeding (Ball, 2003; Gettler & McKenna, 2011). Others argue that the facilitation of sleep development and self-regulation is important for infants, as well as their parents. Breastfeeding, while suggested to be “optimal” as a feeding method for young infant nutrition (Horta, et al., 2007; Ball, 2003) is not the only source of nutrition an infant may have, whereas good sleep is necessary for health and wellbeing, especially for infants who are developing at a rapid rate.

The aim of the current research is to investigate the influence of feeding experience and history on sleep development over the first year of life.

1. Development of sleep

Human sleep follows a circadian rhythm of wakefulness and sleep, which is entrained by the day and night cycle of the environment (Turek, 1998). Infant sleep patterns are different to those of adults. Young infants typically sleep for large periods of the day and night, waking regularly for feeding or other care (Hiscock, 2008). During the first few months of life, a diurnal pattern begins to structure the sleeping pattern, so that bouts of waking begin to be longer and more frequent during the day, while there is more continuous sleep at night (Blampied & Bootzin, 2013).

A newborn sleeps on average 16 hours over a 24-hour period, with four hourly cycles of sleep and waking occurring throughout (Blampied & France, 1993). Over the first few months of life, the length of both the sleeping and waking phases increase, and a diurnal cycle emerges so so that infants spend longer periods of time

asleep during the nocturnal period , separated by sustained periods of time awake increasing during the day (Henderson, et. al, 2010; Simard, Lara-Carrasco, Paquette, & Nielsen, 2011).

1.1 The structure of sleep.

1.1.1. Physiological sleep development. Infant sleep cycles of rapid eye movement (REM) and non-rapid eye movement (NREM) phases typically last 60 minutes, which is shorter when compared with an adult's which is approximately 90 minutes (Blampied & France, 1993). Further, infants spend half of their time asleep in REM sleep compared with approximately 25% of time for adults. This decreases to 33% of the time when the infant is eight months of age and down to 30% by 12 months (Blampied & France, 1993). Because infant sleep cycles are shorter and REM episodes more frequent, infants are vulnerable to waking after each REM period. This is due to the end of REM periods being associated with heightened arousal, which may cross the threshold of waking. They are, therefore, vulnerable to experiencing frequent full arousals where, after waking up, the infant may cry or signal for parental attention (France & Hudson, 1993), unless they have learned to self-soothe and resume sleep without signalling distress.

The longest sleep period (LSP) is a physiological measure of sleep and is defined as the longest sustained sleep period that precedes an arousal or awakening (Anders, Halpern, & Hua, 1992). The greatest changes in the length of the LSP are within the first three months of life with the average LSP of 3.0 to 4.5 hours at one month and 6.2 hours at two months (Henderson, France, & Blampied, 2011). This is consistent with other studies showing that the average LSP is around four hours at birth, and increases to around eight hours by four months (Wolfson, et al., 1992; Elias, Nicolson, Bora, & Johnston, 1986).

The LSP is not sufficient to describe the ecology of the development of sleep consolidation, as it does not identify both the physical and behavioural components that comprise sleeping through the night (Henderson, et al., 2010). This is because sleeping through the night can be a continuous period of sleep or sleep periods with awakenings and self-initiation of sleep (Henderson et al., 2010). A developmental trajectory into sleep consolidation would require the infant to be physiologically capable of a long LSP, and behaviourally capable of self-soothing to resume sleep after awakening, without the need to signal for a parental response.

1.1.2. Behavioural sleep development. The longest self-regulated sleep period (LSRSP) is a period of sustained sleep, quiet wakefulness, and the ability to “resume sleep” without parental intervention (Henderson, et al., 2010). Throughout the night, infants experience numerous arousals and occasional waking; however if an infant is able to self-initiate sleep following an awakening, they appear to sleep longer as they do not require a parental response to resume sleep. The LSRSP includes the longest sleep period (LSP), as well as periods of quiet awakening following a full arousal (where an infant is awake but does not cry or signal to their parents) (Henderson, et al., 2010). The longer the duration of an infant’s LSRSP, the greater the infant’s behavioural capability to maintain settled sleep. Throughout the first year of life, the LSRSP increases dramatically. In a study by Henderson, et al., (2010) it was found that the largest increase in the LSRSP mean duration occurred from one to two months of age. The second largest increase occurred from two to three months, by which time the mean LSRSP duration was 488.3 minutes (Henderson, et al., 2010). The study reported that the total mean increase in duration from one to four months was almost three hours, and that there were small, variable LSRSP duration increases thereafter until 12 months.

1.2 Definitions of sleeping through the night. ‘Sleeping through the night’ is a term typically employed by researchers to describe an infant achieving a specified period of consolidated uninterrupted nocturnal sleep. Over five decades ago, Moore and Ucko (1957) introduced the seminal definition with a criterion that an infant must sleep uninterrupted from midnight to 5.00 am for four consecutive weeks to be considered sleeping through the night.

Similarly, Pinilla and Birch (1993) defined sleeping through the night in their study as an infant sleeping uninterrupted from midnight to 05.00 am. Wolfson, et al., (1992) did not specifically define what constituted an infant sleeping through the night, but reported a variable in their study for infants who were able to sleep for 300 minutes, which assumed the uninterrupted period of sleep is five hours as Moore and Ucko (1957), and Pinilla and Birch (1993).

From a developmental perspective, infants have demonstrated the capability to sustain durations of uninterrupted sleep beyond Moore and Ucko’s criterion from an early age (Henderson, et al., 2011). Parental definitions and expectations of sleeping through the night are also shown to exceed Moore and Ucko’s criterion, believing that infants should be able to sleep for 9.6 hours on average to coincide with the families’ typical sleeping patterns (Henderson, Motoi, & Blampied, 2013), rather than Moore and Ucko’s (1957) five hour duration. Henderson et al., (2010) measured infants’ ability to meet three different sleeping criteria; namely Moore and Ucko’s five-hour criterion; an eight-hour criterion; and an eight-hour criterion with a sleep period from 10:00 pm to 6.00 am, which coincides with the sleeping patterns of the other family members. The findings from this study suggest that infants are capable of sustaining sleep throughout the night from an early age, as most infants met the five and eight

hour criteria by two months of age, but only 50% of the infants met the 10:00 pm to 6:00 am criteria by five months of age.

2. Infant sleep disturbance

There are many different forms of infant sleeping problems. Parents who consider their infant's sleep to be problematic must be aware that it is an issue and want to receive help to change it. Some parents do not view their infant's sleep as disrupted, regardless of what the judgment of an independent observer might be, as they consider their child's behaviour to be normal for infants of that age (France, Henderson & Hudson, 1996; Sadeh, Flint-Ofir, Tirosh, & Tikotzky, 2007). However, around 20 – 30% of children experience problematic sleep before they are three years of age (Sadeh, 2005; Sadeh, Mindell, Luedtke & Wiegand, 2009).

Bed refusal is defined as an infant refusing to go to bed by making demands, crying, and throwing tantrums. Sleep-onset delay is displayed by an infant protesting when then have been first put to bed by crying and calling out for a length of time, instead of settling to sleep. Night waking occurs when an infant who has first settled to sleep then wakes one or more times during the night and cries until a parent comes and tends to them. Co-sleeping is defined as parents choosing to share a bed with their infant in order for them to sleep (France, 1994). Total sleep time measures the length of time an infant is asleep for throughout the night. It allows researchers to calculate exactly how long the infant is asleep, and how long they are awake over a night time period. The more time it takes an infant to settle to sleep and the less total sleep time they achieve, the more problematic their sleep is likely to be.

2.1. Night awakenings. There are three aspects commonly used to measure infant sleep quality: night waking, sleep-onset latency or delay, and total sleep time. As noted above, throughout the night, infants go through REM/NREM sleep cycles and may experience increases in arousal at the end of REM phases. Full arousals typically result in the infants experiencing a full awakening, and therefore infants may awaken regularly throughout the night. Objective reports indicate that on average infants less than 12 months of age may typically have around three awakenings a night (Anders, 1979). Following a night awakening, some infants may resume sleep while other infants may signal, or require parental intervention for sleep resumption.

Over the first year of life, the number of night awakenings an infant experiences will typically decrease in frequency and duration, as they are able to have their longest sleep period during the night. This is consistent in numerous studies that show as an infant becomes older they develop greater self-soothing skills and are able to self-regulate their sleep resumption skills, as evidenced by the decrease in number of night wakings (Henderson, et al., 2010; Beijers, Jansen, Riksen-Wolraven, & Weerth, 2011). While awakenings during the night are normal, many parents find that their infant's disrupted sleep is a major concern, for example, parents in a Swedish study reported infant sleeping problems to be more stressful than child health problems (Sepa, Frodi, & Ludvigsson, 2004).

3. Methods of measuring sleep

There are many methods of measuring infant sleep, both objective and subjective. The most common subjective method is for parents to complete an infant sleep diary detailing the infant's bedtime, pre-bed routine, any awakenings in the night, and what the parents did in response to those awakenings (Henderson et al.,

2010). The reliability of infant sleep diaries can be limited due to the accuracy of parents' recall of the infant's sleeping behaviours, for example, whether they are aware that their infant has woken up (Sadeh, 2004). However, when used in conjunction with other measures such as objective videosomnography (Anders, 1979) or actigraphy, infant diaries can also provide detailed information about an infant's sleeping habits (Mindell, 1999; Galland, Taylor, Elder, & Herbison, 2011).

Videosomnography, or infrared time-lapse video recording (TLVR), is an objective observational method for assessing infant sleep where video equipment and a microphone is set up by an infant's cot to record their sleep and wake behaviour (Anders, 1979; Anders, et al., 1992). It is frequently used by researchers to establish the reliability of parent diaries and to record infant sleep state development (Henderson, et al, 2010; France & Blampied, 2005; Healey, France & Blampied, 2009). High rates of inter-rater reliability have been reported between subjective measures of parent and infant behaviours, and the objective measure of TLVR. For example, the number and duration of night awakenings, time to sleep onset and time awake in the morning in infants under the age of one year (Henderson et al., 2010; Healey et. al., 2009).

4. Feeding method and infant sleep

4.1. Breastfeeding. There are many well-known benefits to breastfeeding infants, but there are also benefits to their mothers. Mothers who breastfeed are found to have a reduced risk of developing breast cancer, Type 2 diabetes, and ovarian cancers with the relationship showing that the longer a woman breastfeeds the better protection she will have (Horta, et al., 2007). This is important to note as the worldwide consensus is to encourage at least six months of breastfeeding for a mother

and her infant (Horta, et al., 2007; National Breastfeeding Advisory Committee of New Zealand, 2009). While breastfeeding is encouraged for its health benefits to both mother and her infant, there are also many psychological benefits of breastfeeding in terms of attachment and the bond developed between mother and infant. Britton, Britton and Gronwaldt (2006) found that mothers who breastfed displayed greater sensitivity in their interactions with their infant at three months of age than mothers who bottle-fed their infants. This was suggested to be the result of mothers initiating breastfeeding, being more responsive to cues from their infants, deciding to breastfeed before their infant was born, and partially or exclusively breastfeeding for longer periods during infancy.

Sadeh, Tikotzky, and Scher (2010) conducted a review examining the bidirectional links between parenting and infants sleep. They found breastfeeding to be associated with more frequent night wakings and a lower percentage of self-soothing from studies utilising parental diaries. Furthermore, infants who fall asleep with high parental involvement are more likely to be unable to self-regulate and soothe themselves, leading to more parental interventions during the night in response to night waking. Breastfeeding has been associated with sleeping problems in infants. It has been found that infants who were partly or exclusively breastfed at five months were at an increased likelihood of having a sleeping problem, including night waking (Schmid, Schreier, Meyer, & Wolke, 2010). It was also found that infants who were breastfed were typically five times more likely to wake up frequently at night than infants who have never been breastfed (Schmid, et al., 2010). Further, Mindell, Du Mond, Tannenbaum, and Gunn (2012) conducted a longitudinal study to determine the relationship between breastfeeding and infant sleep. It was found that at baseline when measures were first collected (infants aged between 3 and 12 months), that

breastfed infants woke significantly more often at night than formula fed infants, and that this finding continued and remained significant at three months. At six months, breastfed infants still woke more frequently than formula fed infants, but these differences were not significant.

Frequency of breastfeeding can vary according to parenting approaches used by parents, for example, parents who adopt a “proximal care” approach breastfeed frequently, respond quickly to infant crying, and hold their infants at least 80% of the time between 8:00 am and 8:00 pm. Parents who adopted a proximal care approach were found to feed their infants the most (14 feeds per 24 hours), and breastfed for the longest period of time of the three groups in the study, compared with normative parenting groups from Copenhagen and London (St James-Roberts, Alvarez, Csipke, Abramsky, Goodwin, & Sorgenfrei, 2006). At 12 weeks of age, 85% of proximal care mothers were solely breastfeeding their infant followed by 70% of the mothers from Copenhagen, and only 37% of the mothers from London. At 12 weeks of age, the infants in the proximal care group were found to be night waking and crying more frequently than the infants in the Copenhagen and London groups. However, this finding could be due to the parents co-sleeping with their infant and being more aware of their awakenings than if the infant had been in a separate bed or room.

Elias, et al., (1986) conducted a study comparing typical middle-class American mothers and their infants, with mothers and infants belonging to a La Leche League group (who adopted a proximal care approach). It was found that sleep development differences emerged over time, as both groups did not differ in rates of wakefulness as newborns. However, at two months of age the standard care group infants had a sleep duration median of 6.5 hours, compared to 5 hours for the La Leche League group (Elias, et al., 1986). These differences became more pronounced

as the groups aged; the standard care groups median duration went from eight hours at four months of age, to longer than eight hours throughout their second year. The La Leche League group maintained their five-hour median duration right up until 20 months of age with continued short sleeping bouts and waking during the night.

The relationship between breastfeeding and sleep is an important factor to consider when an infant is learning to self-initiate sleep after a night waking. If an infant associates having a night time breastfeed with being able to fall back to sleep, it will be required at each night waking and the infant may not have the opportunity to learn to initiate sleep by themselves (France & Blampied, 2005). This may occur due to parents believing their infant is hungry, or knowing that the act of feeding soothes the infant back to sleep, therefore the infant falls asleep being fed and in its parent's arms, reinforcing this chain of behaviours for future awakenings.

On the other hand, it has been suggested that breastfeeding improves the sleep of infants. Cohen Engler, Hadash, Shehadeh, and Pillar (2011) found that breastfed infants aged two to four months slept longer on average than infants who were formula fed. This was attributed to melatonin being present in breast milk in higher quantities during the night so infants who were breastfed received these benefits, as infants are incapable of melatonin production.

Opinions within society may influence how long a mother breast-feeds her infant. A Norwegian study found that a common reason mothers gave for cessation of breastfeeding is negative attitudes in society, which then lowers their sense of breastfeeding efficacy (Haga, Ulleberg, Slinning, Kraft, Steen, & Staff, 2012). Another barrier to continued breastfeeding is the need for mothers to return to work after they have used up their maternity leave, with one in three women returning to work within three months (McDowell, Wang, & Kennedy-Stephenson, 2008).

Furthermore, two out of three women who return to work within six months are still trying to maintain breastfeeding (McDowell, et al., 2008). Haga et al., (2012) state that Norwegian mothers have such a high prevalence of breastfeeding because they are allowed full pay for a year while on maternity leave, so they do not have to give up breastfeeding early.

4.2. Bottle feeding. Many infants are bottle fed for a variety of reasons: their mother may not produce enough milk or be unable to breastfeed; there may be health concerns that make breastfeeding unattainable; mothers may need to return to work and cannot continue to breastfeed; or the mother may feel uncomfortable about breastfeeding and decide it is not right for her. Ramamurthy, Sekartini, Ruangdaraganon, Huynh, Sadeh, and Mindell (2012) conducted a cross-sectional study where parents with infants between the ages of birth to 11 months of age completed an online sleep questionnaire. Over the full age range studied, bottle fed infants were demonstrated to have significantly fewer night wakings than breastfed infants, and longer sleep periods between waking. Bottle fed infants have also been shown to display lower average frequencies of distressed behaviour each day, defined as intense crying and fussing, compared with exclusively breastfed infants at six weeks of age, as well as showing no decline in overall sleep time (Lucas & St James-Roberts, 1998). It has also been documented that bottle fed infants have a lower frequency of night awakenings, shorter durations of night awakening, and a lower frequency of feeding during the night than their breastfed counterparts at both one and three months of age (Ball, 2003). Findings from these studies indicate that on average, bottle-fed infants experience more settled sleeping patterns compared to infants who are solely breastfed.

5. Parenting practices and infant sleep development

Parents may have many different practices or behaviours that they use to care for, and interact with their infant, specific to feeding and bedtime routines. There are many opinions about the best methods to employ for setting the context of the sleep onset period in the beginning of the night. These include the level and intensity of parental involvement for parents in helping their infant to fall asleep and maintaining that sleep throughout the night. These opinions will partly be determined by the developmental requirements of the infant. Parents' may need to respond to the infant when they wake and signal during the night up until the age of six months to provide nutritional requirements. However within this age period and as the infant gradually becomes older, these night wakings typically decrease in frequency for the majority of infants. This is due in part to either the acquisition of sleep self-regulation skills and/or no longer requiring the night-time feeds (France, et al., 1996; Sadeh, et al., 2009). Some parents may employ a parenting philosophy that is characterised by encouraging the infant to learn and acquire independent sleep associations (Eckberg, 2002; Hiscock & Wake, 2002; Mindell, et al., 2006; France & Blampied, 2005; Lawton, France & Blampied, 1991). Such a philosophy would advocate for parents not immediately attending to their infant signalling upon awakening, and delay checking on their infant to allow the opportunity to learn the self-soothing skill, so they may eventually self-settle. These sleep onset associations are typically utilized when an infant no longer requires night time feeding for nutritional purposes during the night, from six months of age (France, et al., 1996). There are many empirical studies documenting the effectiveness of leaving infants to learn the skills of self-soothing that do not require parental attention to infants over the six months of age (France & Blampied, 2005; Sadeh, 1994). In contrast, there are several investigations

that claim leaving an infant to cry is neglectful of their needs and will make them unhappy and insecure (Eckerberg, 2004).

In Pinilla and Birch (1993), treatment group parents were recommended to wait until the infant was crying at night before responding (rather than whimpering) and to resist from rocking or feeding the infant back to sleep, instead trying to soothe the infant by re-swaddling, patting, diapering or walking. If the infant continued to cry after all attempts at soothing, a feed may then be offered. By week three infants in the treatment group had larger means for total amount of sleep, longer duration of sleep per episode, and a greater duration for their longest sleep episode. Infants were classed as “sleepers” if they did not awaken between midnight and 5.00 am; by eight weeks of age, all infants in the treatment group were classed as sleepers compared with 31% of infants in the control group. Wolfson, et al., (1992) conducted a study where parents were assigned to either a control group or treatment group before their first child was born. Parents in the treatment group were provided with information on infant sleep and how to encourage early good sleeping habits. It was found that there were significant differences between their control and treatment groups at three weeks of age for a number of sleeping variables. The training group infants slept for longer periods of time, had fewer feeds during the night, slept for more than 300 minutes at a time, and had fewer individual sleep episodes. The study not only found that parents benefitted from training about infant sleep, but they also reported a greater sense of self-efficacy in managing their infants’ sleep.

5.1 Cultural differences. Mindell, Sadeh, Kohyama, and How (2009) studied the differences between a group of Predominantly-Asian (P-A) infants, and a group of Predominantly-Caucasian (P-C) infants. The P-A group reported a 64.7% rate of infants co-sleeping with their parents, compared with 11.8% of infants in the P-C group. However, while infants in the P-C group were found to be more likely to fall asleep independently in a separate room, this was not true for the P-A group who almost always had an adult present at bedtime, regardless of the sleep location. This finding led the authors to speculate that the differences in sleep outcomes between the culture groups was not due to co-sleeping, but is determined according to the level of parental involvement at sleep onset.

Anuntaseree, Mo-suwan, Vasiknanonte, Kuasirikul, Ma-a-lee and Choprapawan (2008) investigated the association between parent practices and infant sleep in Thai infants at three months of age. The authors reported that 95% of parents responded to night time crying by feeding their infants, compared with 4.6% who responded by holding their infant, and 0.3% who responded by ignoring the crying. The number of parents responding to their infant's night time crying by feeding them was very high, however, it appears to be commonplace in Thai culture when responding to night waking. Anuntaseree, et al., (2008) found that only 0.1% of the 3722 Thai infants in their study slept alone in a room by themselves, while 31.6% shared a room with their parents, and the majority (68.3%) shared a bed with their parents. These figures show that it is commonplace for Thai infants to co-sleep with their parents, which may make it more difficult for parents to ignore night crying, however, it does promote breastfeeding during the night due to close proximity.

A study investigating sleep development in Australian and New Zealand infants found that they experienced significantly fewer awakenings, more total sleep,

were less likely to bed-share, and took less time to fall asleep compared with infants from predominantly Asian countries (Teng, Bartle, Sadeh, & Mindell, 2012). The researchers noted that there was an emphasis in these countries on sleep practices that encouraged the infants to be independent and self-soothe from three months of age.

5.2. Scheduled sleeping and feeding methods. There are many different philosophies about the best way to raise infants, and how to respond to their needs. Ezzo and Bucknam (1995), authors of “On Becoming Baby Wise” make several strong statements about how infant feeding and sleeping routines should be structured, and how parents should respond to their infants’ behaviours. The Baby Wise method proposes that parent directed feeding should take place every three and a half hours, with an infant having enforced naptimes one and a half hours or more before feeding (Ezzo & Bucknam, 1995). This schedule is strict and parents are instructed not to deviate from the routine. For example, if an infant falls asleep during a feed and wakes up an hour later from hunger, parents are instructed not to feed the infant until the next scheduled feeding time, regardless of age. The effectiveness of this method is undetermined, as the method has gathered mixed to negative reviews. The leading criticisms for the Baby Wise programme is that it is not medically sound advice, and the programme has been associated with failure to thrive, dehydration and malnutrition, problems with milk supply for breastfeeding mothers, and involuntary early weaning (Aney, 1998).

In one study investigating the preventive intervention of infant sleep problems in very young infants Pinilla and Birch (1993) concluded that breastfeeding did not have to be associated with night waking This was because infants can learn to sleep through the night and still maintain their nutritional requirements while still being compatible with the mothers’ sleeping patterns. The aim of the study was to assess

whether from three weeks if young exclusively breastfed infants could be taught to sleep through the night. It was found that by introducing “focal feeding” between 10.00 pm and midnight the intervention group infants were less likely to require feeding during the night. The volume of milk consumed was measured by Pinilla and Birch (1993) who reported that eight-week-old infants did not require a feed during the night as they compensated by taking their largest feed at 6.00 am. This finding led the researchers to conclude that infants who did not wake during the night for feeding were still able to consume the same volume of milk as infants who wake up to feed. They also found that while the focal feed assisted infants to sleep for longer periods of time during the night, focal feeding alone was not enough to modify sleep behaviour (Pinilla & Birch, 1993).

5.3. Attachment parenting method. Infant demand parenting, also called “Attachment Parenting” and Proximal Care Parenting, is based on emphasising the evolutionary needs and instincts that parents and babies possess. By following this approach, it is believed that parents can avoid crying and sleeping problems by following their natural instincts of responding to their babies’ cries quickly and feeding them on demand, as well as holding them often and sleeping with them (St James-Roberts, 2007). This is not the case, as it has been found that proximal care babies are more likely to wake at night cry until their parents respond compared with “standard care” infants (St James-Roberts, et al., 2006). One of the main proponents of attachment parenting is Dr Bill Sears. His book (Sears & Sears, 2001) encourages parents to form strong early attachments to their infants and this is achieved by being highly responsive to infants and their needs. This is underpinned in the seven “Baby B’s” that form the basis of this parenting style: Breastfeeding, Bonding, Baby-wearing, Balance, Bedding close to baby, Belief in the language value in a babies’

cry, and Beware of baby trainers (Sears & Sears, 2001). The “Baby B’s” describe the tools that aim to make parents more sensitive to their infant’s cues and enhance the confidence of parents. The attachment parenting method encourages parents to rely on their parenting instincts, such as co-sleeping and responding frequently to their infants if they call out or cry, which is a strong contrast to the method advocated by Ezzo and Bucknam, (1995), which advocates strict routines, no co-sleeping, and leaving infants to cry. Attachment parenting/Proximal Care parenting has been found to reduce crying in one to three month old infants by 50% (St James-Roberts, 2007). However, it does not affect un-soothable crying bouts which can be experienced by infants with colic and was found to lead to increased frequencies of infant night waking.

5.4. Mixed method parenting. Parenting practices used by parents may not fall into purely attachment parenting or infant scheduling, so a combination of the two approaches may be used. A mixed method approach to parenting may occur from mothers needing to return to work, or if there is a change in their infant’s needs requiring an increase in responsiveness from the mother. Parents may begin by embracing an attachment parenting approach, and then progress onto more structured routines such as the Ferber method (Ferber, 2006) as the infant gets older or the parent judges them to be too demanding (Ball, 2003). Parents may also decide to alter their parenting methods if the infant is unwell, or develops sleeping problems that the parents find problematic, resulting in the need for a sleep intervention.

St James Roberts, et al., (2006) studied what differences there were between infants and parents between three different parenting-style groups. The Proximal care group were defined by holding their infants greater than 80% of the time between 8:00am and 8:00pm, frequent breastfeeding, and rapid response to infant crying. The parents recruited from London formed the second group and were defined as using a

“Western” style of care involving more structure and routines, compared with parents residing in Copenhagen. The Copenhagen parents formed the third group, and were expected to be more responsive, and spend more time in contact with their infants, than the parents from London. The majority of parents in all three groups were highly educated, White-Europeans in stable relationships. The study found that there were different costs and benefits to each approach: Copenhagen parents and the Proximal care group experienced less overall crying per 24 hours, however the Proximal care group had more night waking and crying during the night at 12 weeks of age. Regardless of parenting style, all groups had the same level of un-soothable crying in early infancy.

6. Factors associated with disrupted sleep

Parenting practices and philosophies can differ hugely between countries, and even within towns. Some parenting practices, such as co-sleeping, are discouraged in Western cultures (Moon, 2011), however it is the socially accepted norm in many Eastern countries (Mindell, et al., 2009).

6.1. Teething. The occurrence of infant teething has been implicated in night waking. Macknin, Piedmonte, Jacobs, and Skibinski (2000) conducted a study with 125 infants recruited from a four-month “well child” health visit. The study found that increased night waking and decreased sleep duration were present in the days close to a tooth eruption, as well as general irritability.

6.2. Co-sleeping. Co-sleeping is defined as parents and infants sleeping together in an adult bed (Hunsley & Thoman, 2001). There is debate in the literature about the presence of co-sleeping increasing the number of infant sleeping problems and self-regulation issues. There is also a question of safety as the American Academy of Pediatrics (Moon, 2011) recommends in their policy statement about Sudden Infant Death Syndrome (SIDS) that parents should avoid bed sharing as it may cause suffocation, strangulation, or entrapment.

St James-Roberts, et al., (2006) found that rates of co-sleeping differed between three different parenting groups in their study. At 12 weeks of age, 70% of parents in the proximal care group co-slept with their infants for the entire night followed by Copenhagen parents (16%), and then the London parents (9%). The same pattern of bed sharing was shown for infants who only spent part of the evening co-sleeping with their parents, with 70% of the proximal care infants sharing a bed with their parents for part of the night. There were 16% of Copenhagen infants co-sleeping for part of the night, and only 11% of the London infants co-slept with their parents for part of the night.

In a study by Elias et al., (1986) it was found that co-sleeping and weaning status were significant predictors of disrupted sleep status, and that sharing a bed was the most important factor when it came to predicting an infants' longest period of sleep. This finding was replicated for all infants at every age measure in the study from two to 24 months of age. Those infants who were nursed and shared a bed at 24 months had median sleep duration of 4.8 hours compared to infants who were weaned and slept alone (9.5 hours). Infants who were not sharing a bed but were still breastfed had an intermediate median of 6.9 hours. While co-sleeping leads to more disrupted sleep for parents and infants (Elias, et al., 1986; Hunsley & Thoman, 2001), there is

evidence to suggest that it can improve the likelihood of breastfeeding, and encourage mothers to breastfeed for longer (Ball, 2003; St James-Roberts, et al., 2006).

7. Explanatory models for the interaction between sleep and feeding

7.1. Breast-milk Composition Model. Breastfeeding is known to have effects on the quality and quantity of infant sleep, but the precise mechanism behind this relationship has not yet been fully explained. One theory is the breast-milk composition model. Infants are born requiring close mother-infant contact in order for them to develop healthily, and a large component of this contact involves breastfeeding. Breastfeeding is beneficial for both mother and infant, as it helps the attachment relationship form as well as providing nutrition for the infant. However, several studies have shown that infants who are breastfed wake more frequently in the night which is argued to be caused by the chemical composition of breast milk (Ball, 2003). The precise composition of breast milk varies according to maternal diet; however, its predominant composition is carbohydrates, fats, protein and minerals, as well as important hormones and antibodies that boost a young infant's immune system (Arora, McJunkin, Wehrur & Kuhn, 2000). It has been suggested that infant sleep may be affected if a mother has a diet that is high in dairy products containing cow's milk, which is unsuitable for infant digestion (Lucas & St James-Roberts, 1998).

This model is challenged by the fact that infants are physically able to sleep through the night by the time they are six months of age or earlier, with one feed during the night (Henderson et al, 2010). A review of the literature about infant sleep consolidation investigated the LSRSP in eight studies and found that a rapid change occurred between one and four months (Henderson et al, 2010). The study found that

infants were getting seven or more hours of self-regulated sleep by three months of age. This suggests that the chemical composition of breast milk is not affecting the infants' ability to sleep through the night.

7.2. Parental Practices Model. Blampied and France (1993) describe how parent and infant behaviour can contribute interactively to facilitate or delay sleep onset and to change the frequency of night waking. Their behavioural model accounts for these changes by addressing the factors involving sleep self-initiation, sleeping through the night, and parental responses to infant behaviour (Blampied & France, 1993; France & Blampied, 1999). The parenting practices model embodies a component of Blampied and France's behavioural model (1993). Parents of infants may inadvertently reinforce night waking as they misinterpret infant cues or engage in parenting practices that are incompatible with an infant being able to self-regulate (Adair, Bauchner, Philipp, Levenson, & Zuckerman, 1991; Sadeh, et al., 2007). Parents may interpret their infant's signals or crying at night as a sign of unmet needs, and attend to them immediately offering a feed or comfort and not giving the infant an opportunity to self-soothe or self-regulate (Sadeh, et al, 2007). By six months of age, an infant will be neurologically and physiologically capable to sleep through the night as their sleep structure is now similar to an adult, and therefore there is no reason to bottle or breast-feed during the night (Wolke, Meyer, Ohrt, Riegel, 1995).

This model is supported by Ramamurthy, et al., (2012) who found that parenting practices had a moderating effect between breastfeeding infants back to sleep and reduced sleep consolidation. The authors' suggest that parental behaviours at bedtime and during night awakenings are more likely to disturb infant sleep, rather than the act of breastfeeding. This is suggested by the finding that infants who are nursed back to sleep at night (breast or bottle-fed) have significantly more night

awakenings during the night, as well as shorter periods of consolidated sleep (Ramamurthy, et al., 2012). Infants learn how to sleep through the night based on their development and environmental cues. However, if parents mistake awakenings for signs of hunger and feed their infant back to sleep, the infant does not get the opportunity to self-regulate and forms an association of feeding being necessary for resumption of sleep (Wolke, et al., 1995).

8. Rationale for the current research

Parental knowledge about sleep consolidation in infants is widely varied, particularly in reference to the different parenting approaches used. Sleep consolidation is an important milestone for infants to reach and there is the question of whether feeding method influences the developmental timing of sleep consolidation. Data in infant sleep studies is often aggregated over time, which can make it difficult to compare studies based on the age ranges used. It is beneficial to have longitudinal data analysed month by month to show developmental trends in both feeding and sleeping. The purpose of the current research is to ascertain whether an infant's method of feeding affects when they develop the ability to sleep through the night. If there is a relationship between feeding method and sleep consolidation, it will be attempted to be explained, as will any additional variables that need to be considered as having a potential mediation effect. A longitudinal study design will be used as it provides the opportunity to observe developmental trends in feeding and sleeping behaviours month by month across the first year of life for the participants in the study, as well as any changes that occur over time.

8.1. Research aims. The first aim of the present study is to assess infant feeding experience and sleep development over the first year of life. This will be done by analysing the instances of night waking across 12 months, and three “sleeping through the night” criteria previously used by Henderson (2002). Based on the three criteria, it will be possible to distinguish when infants begin to sleep through the night, and whether they are being breast or bottle fed as the primary feeding method at that time. The second aim is to compare Composite Sleep Scores when the infants are six and 12 months of age, between infants who are bottle or mixed fed and the group of predominantly breastfed infants to determine if there are differences in sleep outcomes.

It is hypothesized that infants who are breastfed will have more instances of night waking and take longer to sleep through the night than the infants who are bottle or mixed fed.

Method

1. Participants

The participants in this study were 52 infants and their parents, and were a subgroup from a larger longitudinal study conducted by Henderson (2002). The participants were recruited by Community Health Nurses who distributed recruitment information to parents with a newborn on the Health Nurses’ first home visit following the birth. Newspaper advertisements were also used, as well as flyers distributed at antenatal classes at a local maternity hospital and a neonatal ward at another large maternity hospital (see Appendix A). The inclusion criteria were that the infants were born at term, healthy at birth, and typically developing according to their parents. There were 75 infants in the larger study with the subset for this study (52

participants) chosen on the basis that parents had returned sleep diaries when the infant was one month of age. The diaries needed to include sufficient data to examine the potential relationship between feeding method, in particular the extent of exposure to breastfeeding, and sleeping habits.

The family demographic data is shown in Table 1: 58% of the infants were male and over half were firstborn (63.5%). The mean maternal age was 30.2 years ($SD= 3.51$), and the mean paternal age was 32.6 years ($SD= 4.50$). Birth order percentage was similar between the breast fed and non-breastfed group; 14 breastfed infants were firstborn compared with 19 non-breastfed infants. Socio-demographic status was assessed using the Elley and Irving Scale (2003). The sample was more representative of families of high Socio-Economic Status (SES) (59.6%), while only 1.9% were considered to be of low SES. The percentage of middle-to-high SES families and middle-to-low SES families was 34.6% and 3.8% respectively. The overall group mean SES of the sample was 2.6 (out of 6). The low SES group is under-represented compared to New Zealand norms of 25.3% (Statistics New Zealand, 2006), while the high SES group is over-represented as the New Zealand norm is 28.7% (Elley & Irving, 2003).

Approximately half of the parents (46.2% mothers and 53% fathers) had university qualifications. Of those without university qualifications, 50% of mothers and 37.3% of fathers had high school qualifications, and only a small number (13.6%) had no formal educational qualifications. This shows that overall parents in this sample were well educated.

Table 1: Socio-demographic characteristics of the participants

	Male	All infants		Brf		nBrf	
		n= 52	%	n=23	%	n=29	%
Child's Sex							
	Male	30	57.7	16	69.6	14	48.3
Birth Order							
1		33	63.5	14	60.9	19	65.5
2		13	25	5	21.7	8	27.6
3+		6	11.5	4	17.4	2	6.9
Socioeconomic Status ^a							
1 & 2		32	61.5	14	60.9	18	62.1
3 & 4		16	30.8	7	30.4	9	31.0
5 & 6		4	7.7	2	8.7	2	6.9
Marital Status							
Single		1	1.9				
Two parent		51	98.1				
Age and Ethnicity ^b							
<i>Mothers</i>							
<i>M</i>		30.2		30.7		29.8	
<i>S.D.</i>		3.51		2.83		3.99	
Range		16		12		14	
Maori		1	1.9				
Pakeha		51	98.1				
<i>Fathers</i>							
<i>M</i>		32.7		32.8		32.4	
<i>S.D.</i>		4.44		3.91		4.98	
Range		24		16		19	
Maori		2	3.8				
Pakeha		49	96.2				
Educational Attainment of Parents							
<i>Mothers</i>							
Postgraduate degree		8	15.4	5	21.7	3	10.3
Graduate degree ^d		16	30.8	8	34.8	8	27.6
High school graduate		26	50.0	8	34.8	18	62.1
No qualification		2	3.8	2	8.7	0	0
<i>Fathers(n = 51)</i>							
Postgraduate degree		8	15.7	5	21.7	3	10.7
Graduate degree		19	37.3	8	34.8	11	39.3
High school graduate		19	37.3	9	39.1	10	35.7
No qualification		5	9.8	1	4.3	4	14.3

Note. ^a Family socioeconomic status as rated on the Elley-Irving Scale (2003), where 1= high and 6= low.

^b Age is measured in years and decimal months.

^c The feeding method at 12 months is divided by infants who are breastfed (Brf), and those infants who are mixed or bottle fed (nBrf).

^d Graduate degree is defined as a degree from a university or other tertiary qualification.

2. Study design

The study used a repeated measures longitudinal research design (Beijers, Jansen, Riksen-Walraven, & Weerth, 2011; Henderson, 2002).

3. Procedure

The Community Nurses provided the researcher with the names of parents they had noted as interested in participating in the study and who gave permission to be contacted. Other parents contacted the researcher directly. During the first contact with parents, the researcher explained the purpose and requirements of the study and determined if the infant was eligible. Parents were also offered the opportunity to have a Time Lapse Video Recorder (Anders, 1979) in their home, and they were offered a copy of the recording. If parents verbally consented to participating in the study, they were sent a consent form, sleep diary and self-addressed free-post envelope. Parents who declined to participate were thanked for their time and interest. The following week the researcher rang the parents and described to the parent how to complete the diary and to anecdotally note any health or other issues that they thought may be relevant to the sleep study. All demographic data was collected during this phone call. When a diary was returned, the parents were rung and thanked, and the diary for the following month was sent out. Parents completed the sleep diaries for six consecutive nights once each month, for 12 months.

4. Measures

4.1. Infant Sleep Diaries. The main measurement instrument was an infant sleep diary (adapted from France and Hudson, 1990) in which infant and parent sleep

related behaviours were recorded by the parents. The sleep diaries recorded the time the infant was placed into the cot, whether the infant was awake or asleep at the time, and the duration of minutes until the infant fell asleep. Parents recorded the time and duration of any night-awakenings, how they interacted with their infant during the awakening, and the final time-up in the morning. A key was also provided as a model for abbreviations representing different behaviours the parent engaged in during the pre-bed routine and following an infant night awakening (see Appendix B).

Parents noted the feeding method used in the diaries as either breastfed or bottle fed, and what time the feeding events occurred in the 24-hour schedule. The diary contained a model demonstrating how to complete different sections of the diary. Two examples were provided showing the parents how to correctly report the feeding method either as Breast Feeding (Brf) indicating the infant was predominantly breast fed, and non-exclusive breast feeding (nBrf) indicating the infant was bottle or mixed-fed. Feeding method was also established from anecdotal notes in the diaries, i.e., “now weaned”, or “now on bottle” as well as notes sent with diaries or during telephone conversations with the researcher. For some diaries, the parents failed to indicate (or it was difficult to determine) the type of feeding method. In these cases, future diaries were examined to determine if the feeding method between the next diaries and the last diary were the same, which indicated no feeding method change was noted. If a parent noted somewhere in the next successive months a change in feeding method, i.e., from breast fed in one diary to bottle fed in the next month’s diary, then the child was categorised as not breastfed (nBrf) in the most recent diary.

4.2. Time Lapse Video Recording. Time-Lapse Video Recording (TLVR) was used to assess reliability if parents consented to its use. The TLVR took place over two consecutive nights and the parents activated the recording when the infant

was put to bed and deactivated it when the infant got up in the morning. Infra-red TLVR is a non-invasive way of determining reliability that allows filming under little or no illumination, so it can be set up by the infant's cot to film through the night without disturbing them. The TLVR equipment was delivered and set up by the researcher.

4.3. Feeding Method. The independent variable of interest in the current study was infant feeding method, that is whether an infant was breast fed or not. Two categories for feeding method were derived from the each monthly diary. These were:

1. Breastfeeding (Brf) was defined as when a parent recorded the infant as regularly receiving a breastfeed in the monthly diary as the infant's primary source of nutrition. This categorization may also include the infant being fed solid foods, as breast feeding (rather than bottle feeding) was still being experienced by the infant.

2. Non-exclusive breastfeeding (nBrf) was defined as when a parent recorded that the infant was either bottle-fed, experienced any combination of bottle and breastfeeding regularly, or was weaned.

For the 12 months of parental recording, the infant's feeding method was assessed, and the infant was as categorized as Brf or nBrf and the data was grouped accordingly. The categorization of the infants into the Brf or nBrf group was based entirely on parent report; no independent reliability check was done on feeding method.

Dependent Variables

4.4. “Sleeping through the night”. Three definitions for “sleeping through the night” were employed to assess any differences between the two groups as to when they first began to sleep through the night.

Criterion 1: The first criterion was as defined by Moore and Ucko (1957), and required the infant to sleep with no interruptions for five hours from midnight to 5:00 am in the morning on at least 80% of occasions.

Criterion 2: The second criterion required the infant to sleep uninterrupted for an eight-hour period during the night without waking and signalling to their parents on 80% of occasions.

Criterion 3: The third criterion required the infant to sleep uninterrupted for an eight hour period from 10:00pm until 6:00 am on 80% of occasions. This period has been described as fitting best with family sleep ecology, that is, the infant is sleeping at the same time as other family members are likely to be sleeping.

4.5. Night Waking. Night wakings were defined as any awakening recorded that were sustained for two minutes or more. Night wakings occurred between the time of sleep onset and the time awake in the morning. Any awakening before 6.00am was called a night waking as this time was still considered night-time according to the Canterbury Sleep Programme.

4.6. Composite Sleep Scores. Composite Sleep Scores (CSS, Richman, 1981) were used to measure the quality of the infant’s sleep patterns by combining six parameters of sleep derived from the sleep diaries. A higher CSS indicates a more disturbed sleep (Richman, 1981) while a lower score indicates a more settled pattern of sleep. The six aspects of sleep were: (i) the average time taken to get to sleep or average bedtime (whichever is worse); (ii) the number of nights that night waking was

observed each week; (iii) the average number of awakenings each night (averaged across a week); (iv) duration of each night awakening; (v) the average of total hours of sleep (per night); and (vi) total hours spent in the parental bed per week. A score between zero to four was assigned to each aspect, so the final score could range from zero to 24 with a higher score indicating more disturbed sleep (see Appendix C).

Composite Sleep Scores have been used in various studies (Scher, 2012; Byars, Yolton, Rausch, Lanphear, & Beebe, 2012), and have a Cronbach alpha of .77 for overall internal consistency, providing validity of this measure (Minde, Popiel, Leos, Falkner, Parker, & Handley-Derry, 1993). The CSS were used to classify each infant as being a Self-Regulated Sleeper (SRS) or a Non-Self-Regulated Sleeper (NSRS) at 6 and again at 12 months of age. To be classed as a SRS, a six month old infant must have achieved a CSS of 7 or less. At age 12 months, the infant must have achieved a CSS of 5 or less to be classed as a SRS.

5. Reliability

5.1. Reliability assessment. Reliability scores were calculated by comparing the sleep diaries and the TLVR over two consecutive nights for the 29 (56%) parents who volunteered to have the TLVR in their homes to record their infant's sleep. The TLVR allowed 12 hours of recording to be stored on 1.5 hours of tape and provided a non-invasive method of determining reliability. Reliability scores for parental report was assessed for the following behaviours: (i) Time infant placed into cot at the beginning of the night; (ii) Infant state when placed into the cot at the beginning of the night; (iii) The frequency of night wakings, and (iv) The time the infant was up in the morning.

Using a point by point agreement ratio (Kazdin, 1982), the levels of inter-observer agreement were calculated separately for each variable. Two researchers independently scored the TLVR recordings and the parent/infant behaviours. For each night of recording, the four variables were coded, and this data was measured against the parent report sleep diary. A positive agreement for both recording systems that occurred within a ten minute was period was defined as a “hit” if scored, and a ‘miss’ if there was no match. The hits were calculated and converted into percentage scores for each behaviour (Henderson, 2002).

Percentage agreements between parent report and TLVR record were as follows: 97% for time down; 98% for infant state when placed in cot; 93% for night wakings; and 97% for time up in the morning. There was a high rate of agreement between objective and subjective records for all four variables, and this is consistent with other studies (Blampied & France, 2001).

6. Data analyses

All diary data was entered in an Excel (2010) spread sheet and frequency counts, means (*M*), median, standard deviation (*SD*), and standard error of mean were calculated. All graphs were completed in SigmaPlot Version 12.1.

Breastfeeding Index (BFI): Feeding method was scored as a dichotomous variable, either Brf or nBrf at each month of age. Each infant was assigned a BFI score based on the length of time they were breastfed. An infant who was not reported as being breastfed in the first month was assigned an BFI of 0; an infant that still reported as breastfed at 12 months received a score of 12 (so the BFI range was 0 to 12). If the infant began weaning during a month, the previous month determined the score assigned for the BFI.

Night Waking: Each infant had their night waking frequency per night averaged to yield a mean night waking frequency each month. The mean number of night wakings is displayed (Table 2) for both feeding groups across the 12 month period. Data was also analysed to determine the median, the mean, standard deviation, range, and standard error of mean of night wakings for each month for each group and effect sizes (ES; Cohen's *d*) were calculated using the formula for the between-groups ES.

$$d = M_{\text{nbf}} - M_{\text{f}} / SD_{\text{pooled}}$$

Sleep Consolidation Index (SCI): Each infant was assigned a number based on the first month the infant met each of the following three criteria: Moore and Ucko's midnight – 5:00 am (SCI-5); the eight hour period (SCI-8); and the 10:00 pm – 6:00 am “family schedule” (SCI-F). Each infant's diaries were assessed to determine when they met each of these three criteria over the 12 months. For instance, a score of four for the SCI-F shows that the infant met the SCI-F criterion in the fourth month. The SCI scores were then analysed separately for each criterion. Each infant's SCI score was plotted against their BFI score with the data also divided according to the sex of the infant, to examine the relationship between sleep consolidation and feeding experience moderated by sex.

Composite Sleep Scores: The parental notes in the diaries about their infants' sleeping behaviours were used to calculate the CSS for each infant, with higher scores indicating more sleep disturbance. The CSS were analysed separately by feeding group via infants who were still breastfed at 12 months (23 infants), and those infants who were nBrf at 12 months (29 infants). The mean, median, standard deviation, range and standard error of mean were then calculated for each group across the 12 months.

Results

The research aims were to assess infant feeding experience and sleep development over the first year of life, analyse sleeping data across 12 months, and to compare sleep outcomes when the infants are six and 12 months of age, between infants who are bottle or mixed fed and the group of predominantly breastfed infants. Possible effects of infant sex were also examined. It was hypothesized that infants who are breastfed will have more instances of night waking and take longer to sleep through the night than the infants who are bottle or mixed fed.

1. Feeding experience

Infants were defined as being breastfed (Brf) if parents reported that they were breastfed only; infants were defined as non-exclusively breastfed (nBrf) if they were reportedly fed by bottle or a mixture of breast and bottle-feeding. Infants were assigned a score on the Breastfeeding Index (BFI) depending on how many months they were breastfed.

Figure 1 shows the percentage of children at each age over the first year who were either Brf or nBrf. At one month of age, there were 47 (90%) infants who were Brf, and five infants who were nBrf. The number of infants being breastfed gradually decreased each month. At six months, there were 38 (73%) infants classified as Brf, and 14 who were nBrf, and at 12 months of age there were 23 (44%) infants who were still breastfed and 29 infants being non-exclusively breastfed.

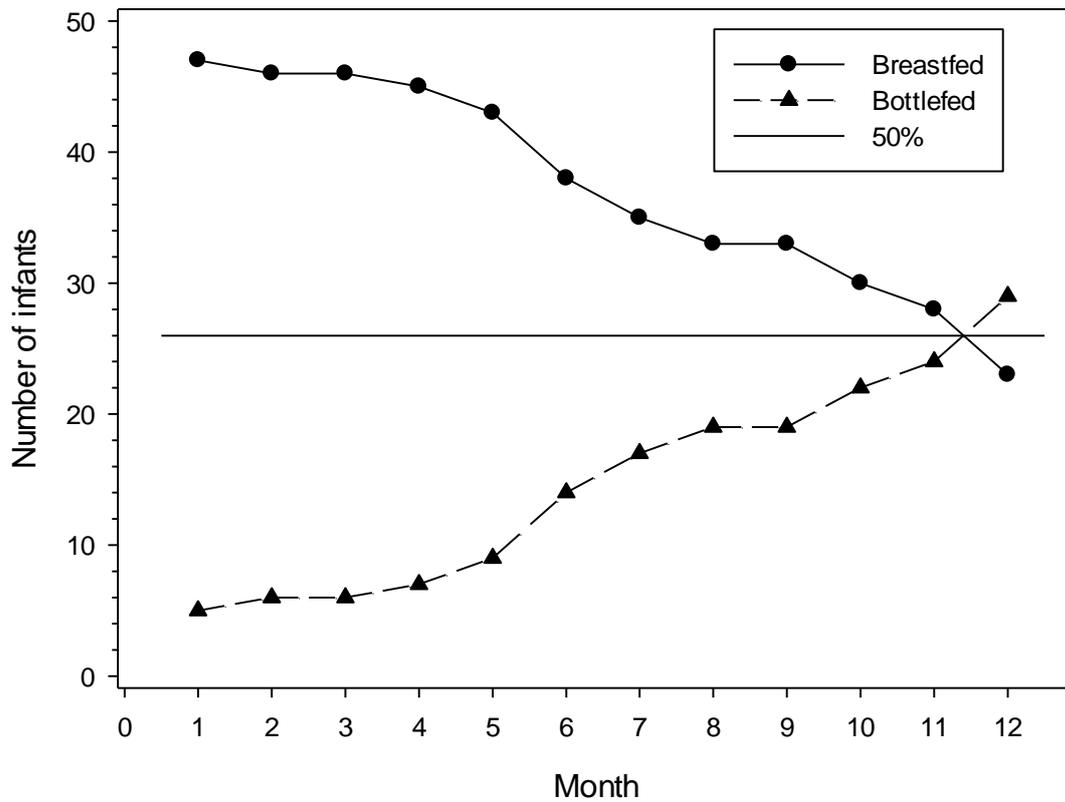


Figure 1: Number of infants either breastfed or not each month over the first 12 months of life

2. Night waking

The means, medians, standard deviations, range, and standard error of the mean for night waking were calculated for each month for the Brf and nBrf group and are shown in Table Two. The monthly mean change in night waking for each group is shown in Figure 2.

Table 2: Mean frequency of night waking across twelve months for Brf and nBrf infants

		Feeding method								
		Brf				nBrf				
Age	<i>n</i>	<i>M(SD)</i>	Median	Range	<i>S.E.M.</i>	<i>n</i>	<i>M(SD)</i>	Median	Range	<i>S.E.M.</i>
1	48	1.35 (.61)	1.33	0.00 - 2.5	0.09	4	1.96 (.80)	2.00	1.00 - 2.83	0.35
2	46	0.89 (.57)	1.00	0.00 - 2.20	0.08	4	1.21 (.76)	0.92	.67 - 2.33	0.33
3	44	0.74 (.73)	0.5	0.00 - 3.17	0.11	7	0.67 (.74)	0.17	0.00 - 1.67	0.26
4	42	0.76 (.82)	0.58	0.00 - 3.00	0.12	10	0.58 (.93)	0.25	0.00 - 3.00	0.28
5	37	1.12 (.93)	0.83	0.00 - 4.50	0.15	14	0.5 (.93)	0.17	0.00 - 3.50	0.24
6	35	1.03 (.82)	0.83	0.00 - 2.83	0.14	16	0.53 (.75)	0.25	0.00 - 2.67	0.18
7	25	1.03 (.93)	0.83	0.00 - 3.00	0.18	19	0.37 (.67)	0.17	0.00 - 2.50	0.16
8	28	1.05 (.98)	0.58	0.00 - 2.83	0.18	22	0.44 (.68)	0.00	0.00 - 2.33	0.14
9	29	1.15 (.91)	1.00	0.00 - 3.17	0.17	22	0.48 (.71)	0.33	0.00 - 3.33	0.15
10	23	0.98 (.84)	0.67	0.00 - 3.17	0.17	24	0.35 (.48)	0.08	0.00 - 1.67	0.10
11	19	0.96 (.85)	0.67	0.00 - 3.00	0.19	28	0.38 (.51)	0.25	0.00 - 2.00	0.10
12	21	1.03 (1.04)	0.83	0.00 - 3.50	0.22	28	0.46 (.59)	0.25	0.00 - 2.17	0.11

Note. Changes in N result from missing data for that month.

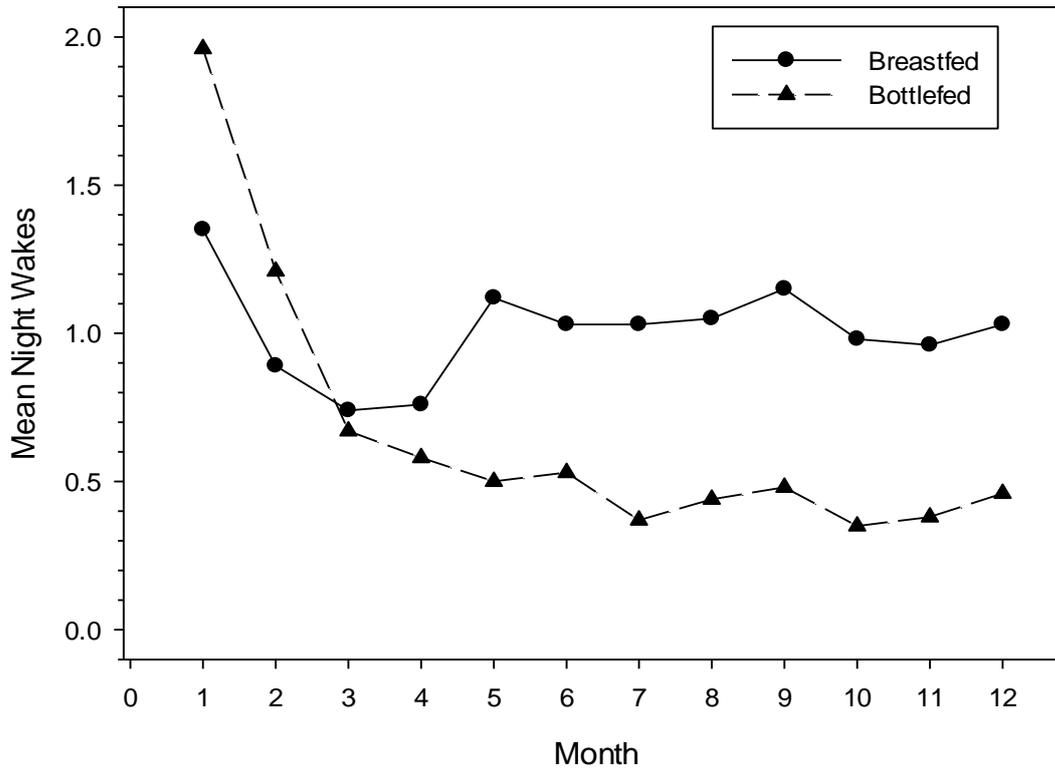


Figure 2: Mean number of night wakes per month grouped by feeding experience

In the first and second months, Brf infants demonstrated fewer mean night wakings compared with nBrf infants (1.35 and 0.89 night wakes for the Brf group and 2.00 and .92 for the nBrf group) (Figure 2). This difference was no longer evident at three months where both groups had the same number night wakings on average. From age four months onward, the Brf group's mean number of night wakings remained relatively stable with one wake on average per night, while the nBrf group decreased to one waking every second night from the seventh month.

Because of the clear inflection in the data paths of Figure 2 at three months, the mean frequency of night waking was calculated over months 1 to 3 (Phase 1) and months 4 to 12 (Phase 2) separately for each group. Breastfed infants had a night waking mean of 0.99 (*S.D.* = 0.64) for months 1 to 3, and a mean of 1.01

(*S.D.* = 0.90) for months 4 to 12. Non-exclusively breastfed infants had a night waking mean of 1.28 (*S.D.* = 0.77) for months 1 to 3, and a mean of 0.45 (*S.D.* = 0.69) for months 4 to 12. To examine the overall effect of feeding experience on night waking, standardized effect sizes were calculated for Phases One (months 1 to 3) and Two (months 4 to 12) as Cohen's $d = \text{Mean Brf} - \text{Mean nBrf} / \text{SD}_{\text{pooled}}$ (Cohen, 1969). For Phase One, Cohen's $d = .45$, indicating that breastfed infants had less night waking. At Phase Two, Cohen's $d = -.70$, indicated that infants who were non-exclusively breastfed had less night waking than their breastfed counterparts. This finding indicates that breastfeeding experience had a small to moderate positive effect on night waking in Phase One, and a moderate to large negative effect in Phase Two.

3. Sleeping through the night

Infant sleep consolidation was determined according to three different criteria previously reported in Henderson et al (2010): Moore and Ucko's (1957) criterion of sleeping uninterrupted from midnight till 5:00 am; the criterion of eight uninterrupted hours of sleep; and the family schedule criterion of sleeping from 10:00pm – 6:00 am. The three criteria will be defined as being part of the Sleep Consolidation Index (SCI) from this point, being referred to as SCI-5 (midnight-5:00 am), SCI-8 (eight hours), and SCI-F (family schedule). They were also grouped according to infant sex (Male or Female) and sleep consolidation was examined as a function of BFI separately for males and females, as shown in Figures 3, 4, and 5. Figures 3, 4, and 5 plot the respective SCI's against the BFI separately for males and females. Note that in these figures, individuals not meeting the criteria were arbitrarily scored 12.5 and their data jittered so the data points do not overlap.

Figure 3 shows that at one month of age there were six infants (12%) who met the SCI-5 criterion and over 55% of the sample meeting the criterion on or before six months of age. Eight infants (15%) comprising two girls and six boys did not meet the criterion over 12 months. Feeding method did not appear to make a difference in the age when infants met the SCI-5 criteria, as there were no systematic effects of BFI evident for either boys or girls.

Relative to Figure 3, Figure 4 shows that there were slightly more infants (four girls and five boys) who did not meet the SCI-8 criterion within 12 months. Otherwise there was, again, no evidence of any systematic effect of BFI on sleep consolidation.

Figure 5 shows the SCI-F criterion, which requires the infant to be able to maintain a family-friendly sleep schedule from 10:00 pm to 6:00 am. This criterion proved to be the most challenging of the three criteria with 16 infants (five girls, 11 boys) not achieving the criterion within 12 months of age. Of the infants who never met the criterion, all but one were breastfed until at least six months of age, with over 80% of those infants being breastfed until 11 or 12 months of age. Infants started to reach this criterion from two months of age (seven infants), with a further nine infants reaching the criterion at three months. Approximately 54% of the infants met the sleep consolidation criterion at or before six months of age. The Pearson product moment correlation (r) between feeding method and meeting the SCI-F criteria was $r = .30$ ns. This suggested that feeding experience had a small influence on sleep consolidation for the infants settling before six months, but breastfeeding is typical for the infants meeting the criteria after six months.

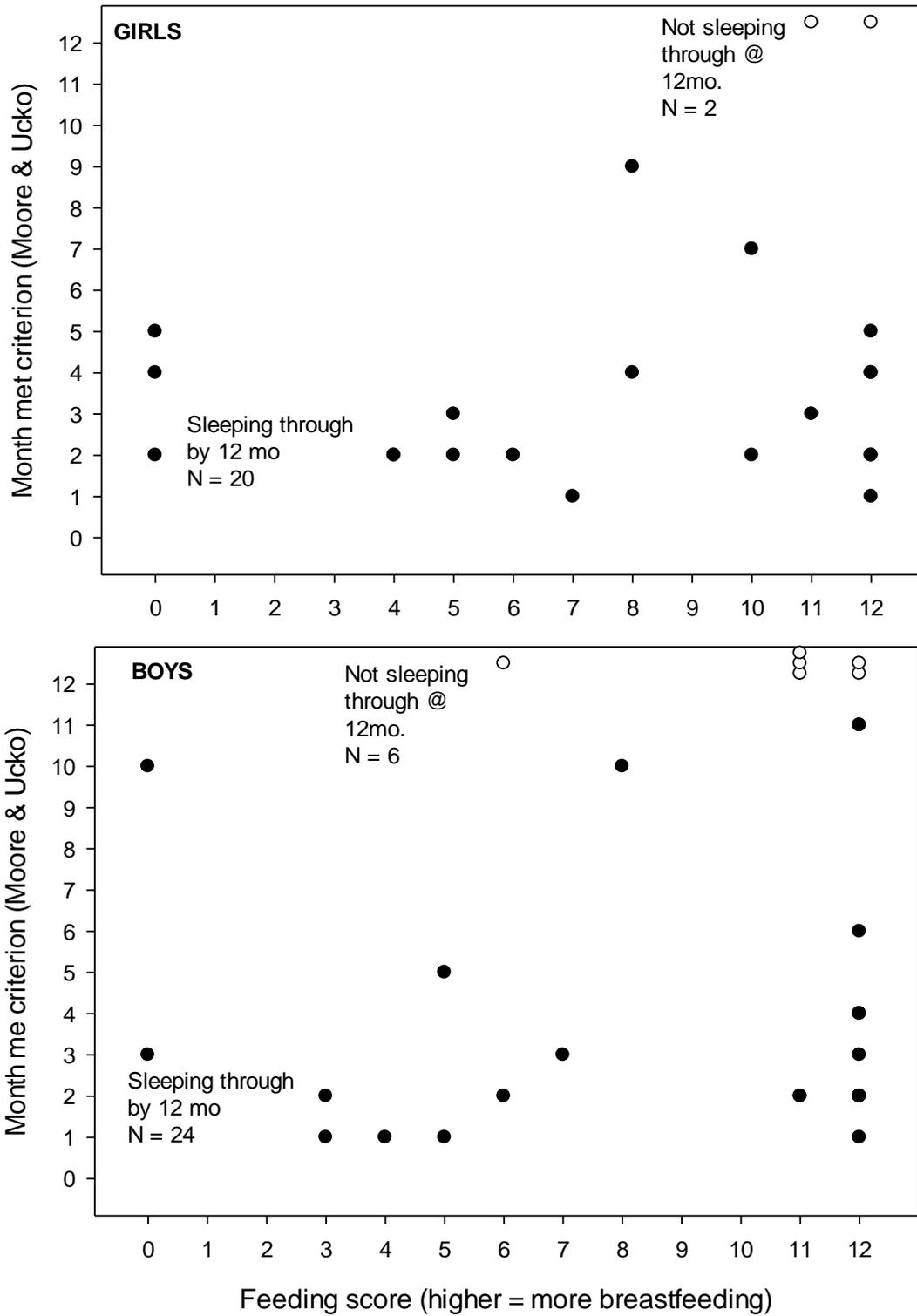


Figure 3: Month infants met the Sleep Consolidation Index -5 (midnight-5:00 am) criterion divided by gender

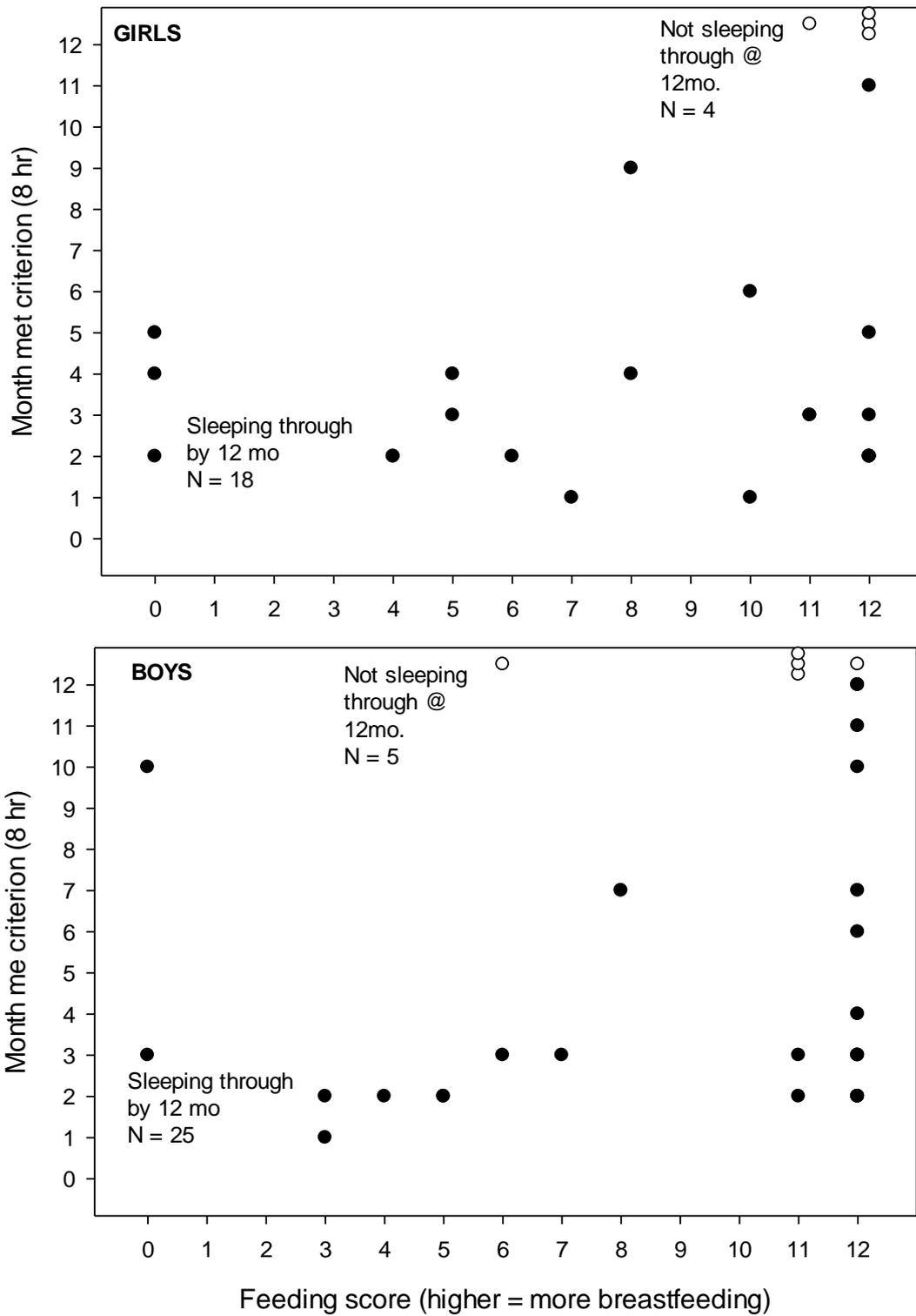


Figure 4: Month infants met the Sleep Consolidation Index - 8 (eight hours) criterion divided by gender

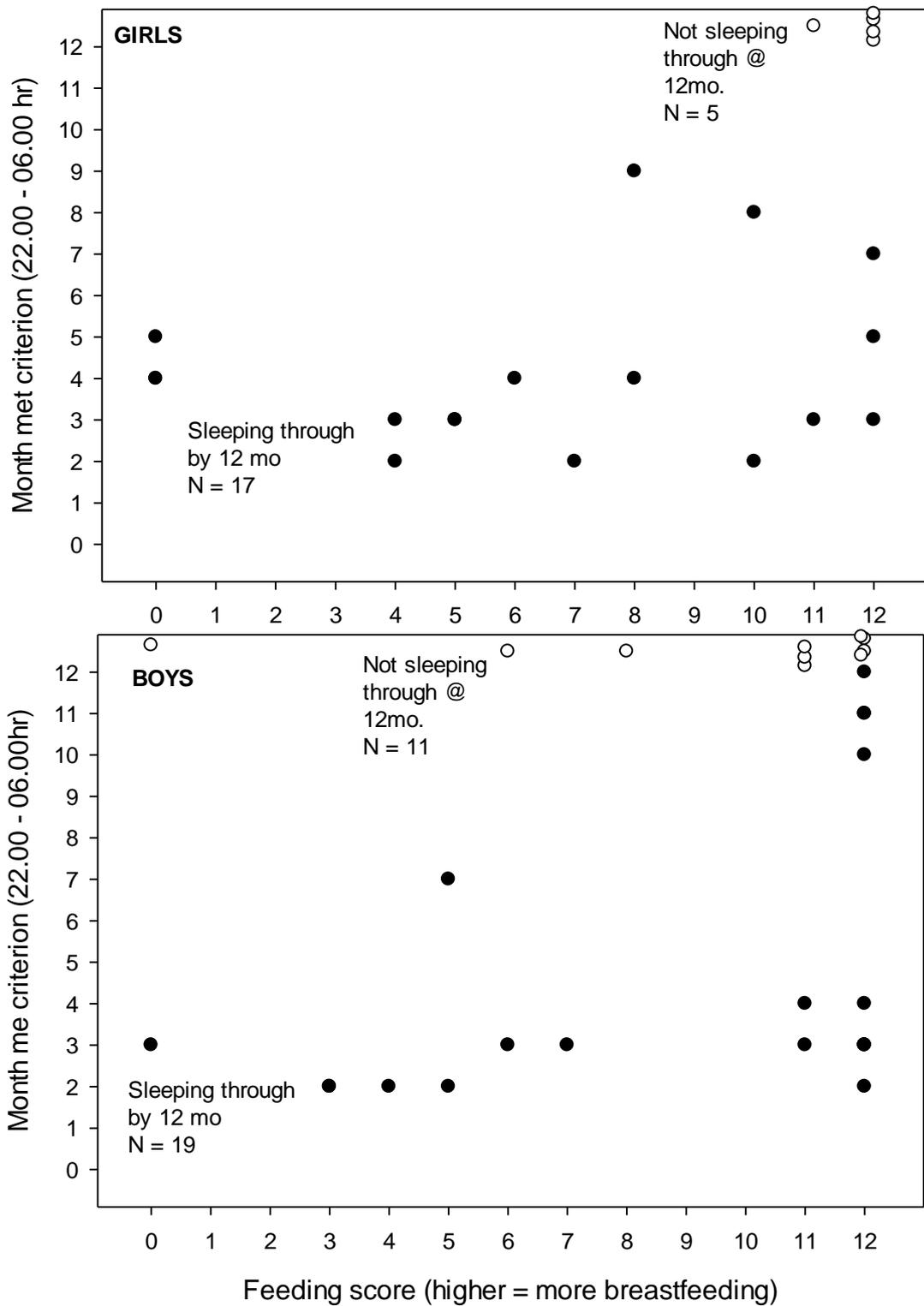


Figure 5: Month infants met the Sleep Consolidation Index -F (10:00 pm -6:00 am) criterion divided by gender

To further examine the relationship between feeding experience and sleep consolidation on night waking, infants were allocated into four groups. These groups were based on their BFI score (greater or less than 6) and whether they achieved sleeping through the night on the SCI-F criterion before six months of age, or after seven months. Six months was used as the dividing point because investigators of infant sleep disturbance have frequently used this as the minimum age for determining the presence of infant sleep disturbance (France & Hudson, 1990; Richman, 1981). This permitted each individual to be classified as Early or Late Weaning (Ew or Lw respectively) and as Early or Late Settling (Es, Ls respectively), yielding four groups. Group One (EwEs) consisted of 14 infants (27%) who had an BFI score of six months or less, and who met the SCI-F before six months. Group Two (LwEs) consisted of 14 infants who had a BFI score of more than six months, and who met the SCI-F before six months. Group Three (LwLs) consisted of 21 infants (40%) who had an BFI score of more than six months, and who met the SCI-F after six months. Group Four (EwLs) consisted of three infants (6%) who had an BFI score of less than six months, and who met the SCI-F after six months.

Figure 6 shows that the average number of night awakenings was similar between Group One (14 infants) and Group Two (14 infants) with both groups sleeping through the night before six months of age. Group Three (21 infants) and Group Four (three infants) who began sleeping through the night after six months of age had consistently higher average frequencies of night waking than Groups One and Two. From this graph, it appears that sleep development status, rather than feeding method, predicts the instance of night waking. This is because the data paths are grouped most clearly by SCI and not by BFI.

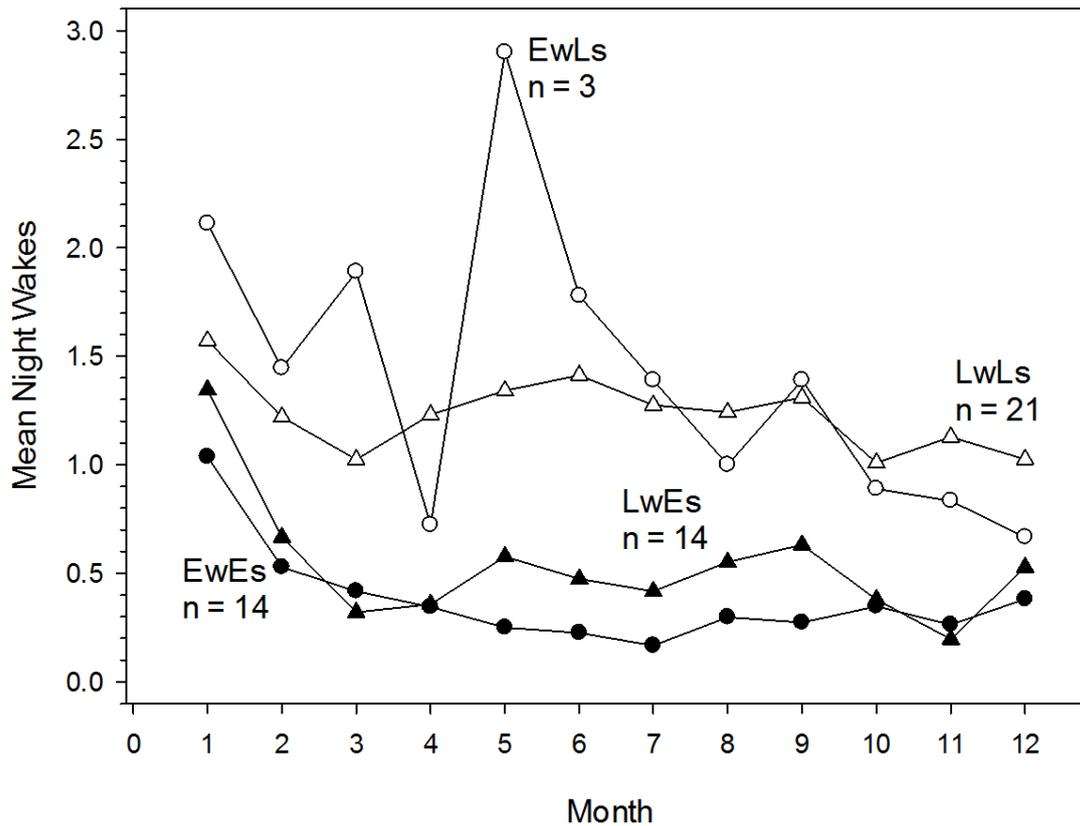


Figure 6: Mean number of night wakes per month divided by Sleep Consolidation Index and Breast Feeding Index scores

Note. Group One – Early weaning, early settling (EwEs) = solid circles;
 Group Two – Late weaning, early settling (LwEs) = solid triangles;
 Group Three – Late weaning, late settling (LwLs) = open triangles;
 Group Four – Early weaning, late settling (EwLs) = open circles

4. Composite Sleep Scores

Composite Sleep Scores (CSS) are a measure developed by Richman (1981) to determine whether an infant can be classed as being able to sustain self-regulated sleep. Mean CSS were calculated at 1, 3, 6, 9 and 12 months, separately for the Brf and nBrf groups and are shown in Figure 7.

Table 3 shows the CSS for the two groups at each age over the first 12 months of life.

Table 3: Composite Sleep Scores across 12 months of age

Feeding method

Age	Brf					nBrf				
	<i>N</i>	<i>M(SD)</i>	Median	Range	<i>S.E.M.</i>	<i>N</i>	<i>M(SD)</i>	Median	Range	<i>S.E.M.</i>
1	23	13.65 (2.59)	14	8.00-17.00	0.54	29	12.97 (2.76)	13	5.00-16.00	0.51
2	23	10.48 (2.81)	10	6.00-18.00	0.59	28	9.18 (4.40)	10	0.00-17.00	0.83
3	20	9.20 (3.69)	10	4.00-16.00	0.83	27	6.81 (4.47)	6	1.00-16.00	0.86
4	21	9.10 (3.24)	9	3.00-13.00	0.71	27	4.93 (4.35)	4	0.00-15.00	0.84
5	21	9.29 (2.75)	9	5.00-15.00	0.59	26	5.69 (4.51)	4.5	0.00-14.00	0.89
6	23	8.91 (3.49)	9	4.00-15.00	0.73	29	4.93 (3.68)	4	0.00-13.00	0.68
7	20	9.10 (3.34)	9	2.00-16.00	0.75	21	4.48 (3.52)	5	0.00-11.00	0.77
8	19	8.95 (3.41)	9	2.00-15.00	0.78	26	4.96 (5.03)	4	0.00-16.00	0.99
9	21	9.67 (3.84)	10	3.00-18.00	0.84	26	4.81 (3.68)	5	0.00-12.00	0.72
10	17	8.53 (4.27)	9	1.00-15.00	1.04	24	4.79 (4.13)	3.5	0.00-13.00	0.84
11	16	7.25 (3.53)	7.5	1.00-14.00	0.88	20	4.30 (3.70)	3	0.00-12.00	0.83
12	23	6.35 (5.36)	5	0.00-21.00	1.12	29	3.17 (3.11)	2	0.00-10.00	0.58

Table 3 shows that the Brf group had higher mean and median CSS than the nBrf group at every age point. The mean scores at one month of age were similar for both groups (Brf = 13.65, nBrf = 12.97), and both groups' mean CSS decreased over the 12 months. Cohen's effect size ($d = -.76$, 95% CI) suggested a large effect for time on the Brf and nBrf groups.

Figure 7 illustrates the mean CSS for the two groups at 1, 3, 6, 9 and 12 months of age. At every month of age, the infants in the nBrf group had lower mean scores compared with the Brf group. This difference was consistently larger from six

months to 12 months of age indicating that nBrf infants demonstrated more settled sleep patterns. At the one month time period the mean CSS for the Brf group and the nBrf group were close at 14 and 13 respectively, however by the three month time period this difference had increased to scores of ten for the Brf group, and six for the nBrf group.

The CSS were measured against the cut-off scores used by Henderson (2002), who found that there was a clear bimodal distribution of the scores at six and 12 months. This distribution defined infants as having scores that made them more likely to sustain self-regulated sleep, and those infants who were unlikely to sustain self-regulated sleep. To be classed as a SRS, a six-month-old infant must have achieved a CSS of seven or less. At age 12 months, the infant must have achieved a CSS of five or less

At the six and 12 months of age, only the nBrf group evidenced means that classified them as SRS ($M= 4.93$, and $M= 3.17$ respectively), while the Brf group were classed as NSRS ($M= 9.00$ and $M=6.35$).

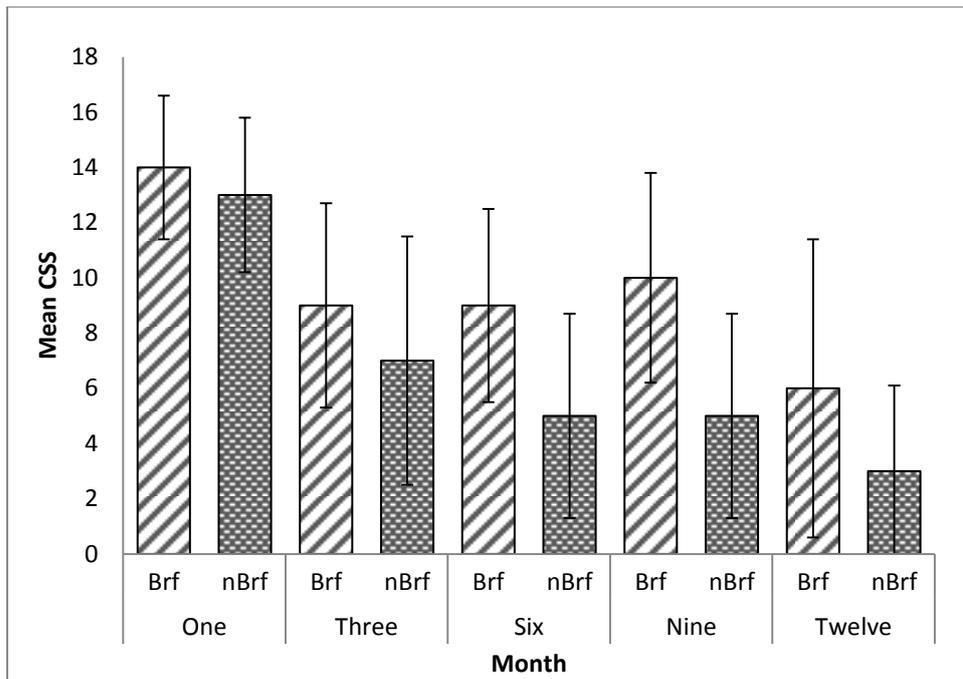


Figure 7: Mean Composite Sleep Score for Brf and nBrf infants at 1, 3, 6, 9, and 12 months of age

Note. Standard deviations for each month are included with the mean CSS.

Change over time in CSS for the Bf and nBf groups was analysed by a 2 x 12 Analysis of Variance (ANOVA) comparing feeding experience (Brf, nBrf) across time (months). The reduction over time in CSS shown in Figure 7 was statistically significant ($F(11,40) = 21.8, p < .05$), but there was no significant interaction of time with feeding experience ($F(11, 40) = 1.62, p > .05$). The main effect of feeding experience was statistically significant ($F(1, 50) = 14.1, p < .05$). This is consistent with the systematically higher scores shown for the Bf group in Figure 7.

Discussion

The aim of the current research was to investigate the influence of feeding experience and history of sleep development over the first year of life. The current study also aimed to determine whether there are differences in sleep development between infants who are exclusively breastfed and those who are not. In summary, the research found that infants who had higher exposure to breastfeeding had fewer night wakings in the first two months, but had more night waking from four months of age relative to non-breastfed infants. The infants with higher exposure to breastfeeding also took longer to achieve the three sleep consolidation criteria and had higher CSS than did their non-breastfed counterparts. The findings of each of these sleep development components are discussed in relation to the results below.

1. Night waking

The first research aim of the present study was to determine whether feeding method has an effect on infant sleep development across 12 months. From the Breastfeeding Index (BFI) infants were assigned a number based on how long they were predominantly breastfed (Brf), and then this number was compared with their average number of night awakenings across 12 months.

The results showed that the Brf infants had lower instances of night waking in the first two months than the nBrf infants, but they had approximately the same amount of night waking as nBrf infants at three months. The Brf infants then had higher instances of night waking than the nBrf infants through until 12 months of age. The effect sizes suggested that breastfeeding exposure had a small to moderate positive effect on night waking in Phase One (months 1 to 3), and a moderate to large negative effect in Phase Two (months 4 to 12). From this data it was concluded that

breastfeeding experience slightly increased the frequency of infant night waking from four months of age and remained at a relatively consistent frequency until 12 months of age.

The results from three months of age align with Galbally et al., (2013), which found that infants who are breastfed at three months are more likely to wake at night, even when other variables are controlled for. An increased level of night waking in breastfed infants is often attributed to their need to be fed more frequently due to the composition of breast milk. In support of this theory, Ball (2003) describes how breast milk is easily digestible for infants, which requires them to feed at two to four hourly intervals. The reported relationship between more frequent night waking in breastfed infants when compared to non-breastfed infants appears to be consistent across studies (Ball, 2003; Simard, et al., 2010; Elias et al., 1986). Weaning status appears to be strongly associated with night waking; breastfed infants sleep in shorter bouts with less overall sleep than their non-breastfed counterparts (Elias et al., 1986).

However, the results found in the first three months of the study dispute these assumptions about breastfeeding and early sleep development. From birth to three months, the Brf infants had lower instances of night waking than nBrf infants. This does not support Ball's (2003) theory that breastfed infants wake more frequently due to the digestion of breast milk, as it would be evident from birth. The finding that the Brf infants slept more than the nBrf infant until three months is supported by Cohen Engler, et al., (2011) who also found that breastfed infants aged two to four months slept longer than formula fed infants due to melatonin being present in the breast milk. Doan et al., (2007) stated that parents of three-month-old breastfed infants slept 45 minutes more on average than parents of formula fed infants due to less infant waking. The finding that Brf infants sleep more than nBrf infants in the first three

months of life show that the literature asserting that Brf infants have worse sleep than formula and mixed-fed infants is inaccurate when applied to the whole of the first year of life.

2. Sleeping through the night

To investigate further the relationship between feeding method and infant sleep development, infant sleep consolidation was examined. This was achieved by measuring the age at which infants began to sleep through the night based on the three criteria previously used by Henderson, et al., (2010). The present study found that six infants were able to sleep through the night (according to Moore and Ucko's 1957 criterion) at one month of age. By three months of age, over half of the infants in this study had met this criterion, and almost three quarters of the infants met the criterion by six months of age. This finding replicated Moore and Ucko's (1957) proposal that infants were capable of sleeping through the night at three months of age according to their midnight to 5:00 am criterion. There were 26 infants (50% of the sample) meeting the SCI-8 criterion by three months of age, with approximately 65% of infants meeting it at six months of age. The SCI-F proved to be the most difficult criterion for the infants to reach; that is, while over 53% of the infants had met the criterion on or before six months of age, sixteen infants never actually met this criterion.

Pinilla and Birch (1993) also used a midnight – 5:00 am sleep criterion to determine whether infants could be taught to sleep through the night at an early age. They found that 100% of treatment group infants were able to sleep through the night compared with 23% of the control group infants at eight weeks of age. Infant feeding volume was also measured, and it was found that treatment group infants as young as

three weeks of age were taking their largest feed at 6:00 am to compensate for sleeping for longer periods at night. This showed that at a young age, infants were able to adhere to a behavioural schedule for their sleep while still being breastfed. It was also shown that infants were not losing any nutrition because they took a larger “compensatory” feed when they awoke in the morning. At eight weeks of age, there were 23 (44%) infants in this study who met this criterion with all but one being breastfed.

Henderson, et al., (2013) conducted a survey with 412 parents who had a child less than two years of age. Parents defined sleeping through the night beginning around 8:00 pm and being sustained until approximately 6:30 am, which is longer than the 10:00 pm -6:00 am criterion (SCI-F) used in this study. This finding by Henderson, et al., (2013) demonstrates that from a parental perspective, it is not unreasonable to encourage infants to sleep according to a schedule that is convenient for the whole family.

3. Composite Sleep Scores

The second research aim was to determine whether the CSS (Richman, 1981) at six and 12 months represented better sleep outcomes for nBrf infants compared to predominantly Brf infants. The results showed that the CSS were larger for the Brf infants across every month for 12 months, and more than double the CSS for the nBrf infants on three occasions. At six months of age, the Brf CSS was 8.91 and the nBrf CSS was 4.93, while at 12 months of age, the Brf group had a mean CSS of 6.35 and the nBrf was 3.17. These CSS demonstrate that the sleep outcomes of the nBrf infants were better than the Brf infants at six and 12 months with the nBrf CSS six month mean being lower than the CSS achieved by the Brf infants at 12 months of age.

There was a large effect of time for both the Brf and nBrf groups. However, the nBrf group showed a larger effect across time, meaning the reduction in scores was greater for the nBrf group.

Composite Sleep Scores have been used in many other studies, particularly studies involving infant sleep interventions. For example, France and Hudson (1990) recorded mean CSS for infants aged 8 to 20 months in a sleep intervention. The mean CSS at baseline was 10.24, but it dropped to 3.82 during the intervention. The mean CSS was 2.29 and 3.34 at the two follow up periods. The infants in this study achieved CSS means of 6.35 (Brf) and 3.17 (nBrf) by the age of 12 months, which is not as low as the scores from France and Hudson (1990), although the infants in this study were not part of a behavioural intervention. The CSS cut-off indicating problematic sleep at 12 months of age was five or less, so the overall nBrf group could be classed as non-problematic, SRS.

4. Unexpected findings

When the three sleep consolidation criteria were examined, four distinct groups appeared to exist within the sample. The first group comprised infants who had a low breastfeeding score and who slept through the night before six months; the second group were infants who had a low breastfeeding score and began sleeping through the night after six months. The third group were infants who had a high breastfeeding score and began sleeping through the night before six months. Finally, the fourth group were infants who had a high breastfeeding score and began sleeping through the night after six months.

It was predicted that infants who were Brf would take longer to reach the three sleep criteria than nBrf infants; however, one of the Brf groups (LwEs) reached the

three criteria before six months of age. This finding was unexpected for two reasons: firstly, due to the significant body of literature suggesting that Brf infants would take longer to achieve sleep consolidation; and secondly, the previous results for night waking in this study. At six months of age, 73% of the infants were classified as Brf, but this number had dropped to 44% at 12 months of age. These results indicate that despite the majority of infants being exclusively breastfed, they are still able to sleep through the night at an early age. Therefore, due to the high level of variability in the relationship between breastfeeding and sleep development, it is not possible to predict sleep consolidation from feeding status alone.

5 Implications of findings

5.1 Sleep and feeding. Infant sleep is one of the most common concerns raised by parents in Plunket meetings and with general practitioners and paediatricians (Henderson, et al., 2013; Mindell, Du Mond, Sadeh, Telofski, Kulkarni, & Gunn, 2011). Therefore, the factors that influence infant sleep consolidation are worth investigating. Breastfeeding is a factor that has been claimed to affect infant sleep consolidation. However, breastfeeding provides vital nutrition to infants, and mothers are encouraged to breastfeed if they can for at least the first six months of an infant's life (World Health Organization, 2001; World Health Organization and UNICEF, 1989).

The findings of this research may alleviate concerns raised by McKenna (2010) who stated that parents cease breastfeeding too early in order to improve their infants' sleeping duration at an earlier age. Many of the infants in this study were breastfed for 12 months and still able to sleep through the night, unlike those in previous research (Pinilla & Birch, 1993; Ramamurthy, et al., 2012). The results of

this study indicate that breastfeeding does not necessarily predict poor sleeping patterns. While Brf infants initially exhibited more night waking than nBrf infants, when the two groups were split according to their BFI score and the SCI-F criterion, it was clear that Brf infants could be breastfed and sleep for eight hours in line with the general family schedule. This finding is vital for parents who want to encourage their infant to sleep through the night, and still want their infant to receive the nutritional benefits of breastfeeding. These findings indicate that breastfed infants are able to maintain good sleeping patterns, so there is no reason for parents to have to decide whether large periods of uninterrupted sleep or being breastfed are more beneficial to their infant.

These findings are similar to those by Elias, et al., (1986). Specifically, from four months of age the breastfed infants in that study experienced a decline in sleep quality, which remained consistently low until 16 months of age. Conversely, the infants who were weaned maintained better sleep than the breastfed infants did at each measure of time. While there were no weaned infants at two to four months (like the current study), Elias, et al., (1986) the findings demonstrate that breastfed infants maintained better sleep quality before four months of age, which is consistent with the present study.

Rates of breastfed infants in Western cultures can be low, which is a source of the debate over promoting an infant to sleep through the night. Galbally, et al., (2013) reported that rates of partial breastfeeding at six months of age in the United States, United Kingdom, and Australia were 43%, 25%, and 49% respectively. This study had 73% of infants being predominantly breastfed at six months with 44% still being predominantly breastfed at 12 months. These feeding results are encouraging for parents who may be concerned that breastfeeding may decrease as a result of

encouraging their infant to sleep through the night, which does not have to happen as this study has shown.

5.2 Parental behaviour. The findings from the current study may be attributed to factors purported in France and Blampied, (1993; 1999). Bio-behavioural models (in Model One, France and Blampied, 1999) focuses on an infant's sleep development from birth to three months, and how infant temperament can be influenced by external factors such as parental behaviour. If an infant is born with physiological vulnerabilities, parenting behaviour may be over responsive or over-stimulating to the infant. This means that the parent may inadvertently take the opportunity to self-soothe away from their infant. Furthermore, if parents respond immediately with feeding, the infant will begin to associate feeding with sleep resumption, requiring feeding as an antecedent to resume sleep. Model Two describes the development of primary sleep disturbance around three to six months of age, and is dependent on the associations made after waking. If the infant is unable to self-initiate sleep, they may signal for their parents, which in turn, reinforces the behaviour chain making the sequence more likely to repeat in future. Model Three describes the development of sleep disturbance in infants over six months of age who have previously slept well.

The findings from this study align with Models One and Two, and the development of disturbed sleep due to associations made after waking. The results for infant night waking showed both the Brf and nBrf infants had approximately the same rates of night waking at three months of age, before the groups diverged for the remainder of the study. As this trend occurred from the age of three months, it is plausible to attribute the differences in night waking to parental behaviour associated with feeding, and whether infants were given the opportunity to self-soothe from one

to three months. When the BFI and SCI-F scores were examined, four groups emerged. There were two groups of Brf infants; one group sustained consolidated sleep before six months of age, while the other did not. As this difference in sleep consolidation cannot be attributed to feeding method, Model Two's theory that parental behaviour may be associated with the absence of self-initiated sleep is further strengthened.

Mindell, et al., (2009) studied the differences between a group of Predominantly-Asian (P-A) infants, and a group of Predominantly-Caucasian (P-C) infants. They found that while infants in the P-C group were more likely to fall asleep independently in a separate room, this was not true for the P-A group who usually have an adult present at bedtime regardless of the sleep location. This finding led the authors to speculate that the differences in sleep outcomes between the culture groups was not due to co-sleeping, but was determined according to the level of parental involvement at sleep onset. This finding may explain this study's results that it is not feeding method that contributes to infant sleep consolidation, but the parental behaviours that accompany infant feeding and other wakings during the night.

5.3 Contributions to the literature. There are currently very few longitudinal studies that contain month-by-month data, (rather than aggregated data), and run for longer than several months. While studies that investigate infant sleep and feeding in the first few months of life (Ball, 2003; Pinilla & Birch, 1993; St James-Roberts, et al., 2006; Simard, et al., 2010) are important, they are unable to provide a detailed account of an infant's development past early infancy when behavioural development associated with sleep becomes more pronounced. This study provides a detailed account of how infant sleep changes each month over the first year of life, and addresses the role of feeding method in relation to sleep development. It also did

so in a sample of infants with high rates of sustained breastfeeding, unlike the situation in many other studies.

6. Limitations

A limitation of this research was not having specific information about when the infants began to have solid food. The World Health Organization (2002) recommends that infants begin having solids from six months of age; however, many infants begin consuming solids at a younger age (Ball, 2003; Grummer-Strawn, Scanlon, & Fein, 2008). An infant could still be in the breastfeeding category but have their feeds supplemented with solids, which would affect their ability to sustain sleep due to rate of digestion. It would have also been beneficial for the parents to note when the infants began teething, as this can increase the likelihood of infants waking during the night (Macknin et al., 2000).

Another limitation to this study is the lack of information regarding parental behaviour when interacting with their infant at night. Numerous studies (Anuntaseree, et al., 2008; Mindell, et al., 2010; Ramamurthy, et al., 2012; Sadeh, et al., 2009) have found that infant sleep is influenced by parental reinforcement when the infant awakens through rocking, feeding, or taking the infant into the parent's bed. These behaviours influence night waking and the ability to sleep through the night, so it would be beneficial to have information about parental behaviours, as well as feeding method, in order to determine what factors are influencing infant sleep.

The family demographics show that the participants in this study were typically from highly educated, two-parent, New Zealand European families with well-paying jobs. This could limit the generalizability to other ethnicities or family groups. However, the participants volunteered to take part in the study through seeing

advertisements in the newspaper and hospitals, and parents were given information from Community Health Nurses,. Therefore, engagement in the study was possible for any parents with a healthy infant.

7. Future research

There are several opportunities for future research to further explain the relationship between infant feeding method and sleep development. The feeding information parents noted was whether their infant was being breast fed or non-exclusively breastfed in general, as well as if they were fed during the night when they awoke. Future researchers could examine the length of feeding or volume of the feed, such as Pinilla and Birch (1993), to determine if infants were waking during the night because they were hungry or whether they had grown to expect a feed from their parents. Also, this study did not ask for information regarding solids consumed by the infants. Information about the age that the infants begin to eat solids and the type of solids they were, may have an effect on sleeping development. An example of this is where parents typically fed their infants a heavy food at night such as baby rice on the belief that it would enable them to sleep better (Ball, 2003).

Infant sleep behaviour was measured in this study in terms of night awakening, length of night time sleep, and sleep time behaviours; however, future research could include measurements of parental behaviour. Parental behaviour has been shown in numerous studies to influence the development of sleep in their infants. If there was an additive relationship between parental behaviour and feeding method, the implications on sleep development would be worth investigating.

Very few studies that report developmental changes month by month, so future research replicates that replicate a longitudinal design with monthly data

measures for infant sleep and feeding development would also contribute significantly to this growing field of research.

8. Conclusion

Many parents of infants are awoken during the night by their infant, and the parents may respond by offering the infant a feed. This study set out to determine if feeding method had an influence on when an infant began to sleep through the night. Breastfed infants displayed more night waking than their mixed or bottle-fed counterparts and took longer to reach each of the three sleeping through the night criteria. When examined more closely, there appeared to be two subsets within the breastfeeding group: those infants who experienced consolidated sleep earlier than six months of age and the infants who did not. While the cause of this finding was not investigated in this study, it shows that infants can still be predominantly breastfed and be capable of sleeping through the night from an early age. This feeding group divide may be explained by parental practices that occur during the night when infants wake to feed, rather than the feed itself. These findings may reassure parents that infants can be predominantly breastfed and still manage to sleep through the night from an early age.

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Appendix A:
Flyers for Recruitment



Education Department

University of Canterbury

Private Bag 4800
Christchurch New Zealand
Telephone: 03-366 7001
Fax: 03-364 2418

CANTERBURY SLEEP PROGRAMME

The Canterbury Sleep Programme (CSP) is wanting to follow parents and their first babies from pregnancy through the first year of life. This is to gain information about their sleep patterns and development. If you would be willing to discuss taking part with us, please fill in the form below and Lynne, our CSP Research Nurse, will phone you.

Name: _____

Telephone Number: _____

Date Baby Due: _____

Lynne Hazlett, Research Nurse
3597-058

CANTERBURY SLEEP
PROGRAMME

WANTED: PARENTS WHO HAVE BABIES
AGED LESS THAN
TWO MONTHS FOR A STUDY ON INFANT
SLEEP PATTERNS

The Canterbury Sleep Programme (CSP) is wanting to gain information on the development of infants' sleep patterns in the first year of life. All it takes is to fill in a simple sleep diary for six nights once a month. If you would like more information please phone Elizabeth, our research assistant at **3667 001 ext. 8214.**

Appendix C:

Composite Sleep Scoring Sheet

Method of computing Composite Sleep Scores (From Richman, 1981)

Av. Time taken to sleep (Min)	<u>Score</u>	Av. Bedtime (whichever is worse)
<15	0	5-8.4 p.m.
16-29	1	8.5-9.2 p.m.
30-44	2	9.3-10 p.m.
45-60	3	10.1-11 p.m.
>60	4	After 11.0 p.m.
Av total time slept at night in hours	or	Av. No. of nights waking per week
12+	0	0-1
11+	1	2
10+	2	3
9+	3	4-5
<9	4	6
Av. No. of wakings per night	or	Av. Time awake per waking (Min)
<0.3	0	0-5
0.4-1.0	1	6-15
1.1-2.0	2	16-30
2.1-3.0	3	31-60
3.0	4	>60
Av. Weekly hours in parents bed (No. Nights x Av. No. hours)	or	TOTAL SCORE
None	0	
1-6	1	
7-20	2	
21-34	3	
35+	4	