



Response-based sleep intervention: Helping infants sleep without making them cry[☆]



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ARTICLE INFO

Article history:

Received 6 December 2016

Received in revised form 16 March 2017

Accepted 21 March 2017

Available online xxxx

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1. Introduction

It is common for parents to raise questions about infant sleep patterns when attending infant well-visits during the first year of life [1, 2]. In seeking answers to their questions from health practitioners, parents have access to a myriad of resources, including family, friends, web-based sites, social media, as well as parenting books. However, these sources of information often present contradictory best practice recommendations [3]. These contradictions are particularly notable in the areas of Infant Total Sleep time (TST) and parental response and presence when infants transition to sleep [4,5]. With the frequency of parents' questions about infant sleep, helping parents to establish healthy sleep patterns during an infant's first year of life is an important concern for researchers and practitioners. At present, between 25% and 40% of families report childhood sleep problems defined by latency to sleep, number of infant night wakings, and inability to return to sleep without parental attention [6,7,8]. Infant night wakings accompanied by infant signaling for attention (e.g., crying) are identified as problematic for parents due to disruptions in sleep, parental fatigue [9] and an association between wakings and maternal depression [10,11].

Given an association between parent presence and infant signaling during nighttime care, recommendations often caution parents against responding to infants during their transition to sleep or when waking

[12]. Based on this goal, most commonly recommended best practices focus on limiting parental presence and response to infant signals for attention during transitions to sleep. These practices include unmodified extinction approaches, such as crying it out or unmodified extinction characterized by parental nonresponse to infant crying [12,13]; modified or gradual extinction-based approaches, such as controlled comforting characterized by continued decrease in parental response and presence when infants transition to sleep [12,13]; or fading routines, such as camping out or scheduled wakings [12,13]. With adherence to behavioral protocols, each of these practices is shown to be effective in training infants to transition to sleep without parental interaction [14,4].

Despite their success, a significant body of research suggests that these recommended behavioral practices may have some drawbacks for both parents and infants. For example, parents have been reported to experience discomfort with leaving an infant to cry to sleep or in limiting presence during transitions [15,13]. Whether parental responsiveness when infants transition to sleep is helpful or hindering for infant emotional development remains an area of controversy [16]. Similarly, the role of responsiveness for infants' developing regulatory systems is debated [17,18,19,20,21]. Finally, questions of whether parent and infant sleep quality is benefited or hindered by parent presence remain unclear [22].

These debates in the research are evidenced in the limited assessment of behavioral sleep approaches. Limiting parent presence as a mechanism to reduce night wakings is supported by the work of Price and colleagues who examined children's development following the use of modified behavioral approaches with infants identified with sleep problems at 7 months of age. Their longitudinal study identified no negative impact in the group of mothers engaged in this behavioral

[☆] Grant information: This research was funded through a 2014 Victorian State Government Department of Economic Development, Jobs, Transport and Resources, Grant to Safe Sleep Space Pty. Ltd. (Innovation Voucher Program Research and Development Voucher (IVP BDR) 123 A,B,C) via La Trobe University.

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sleep program [14]. Mothers engaging in the sleep program were encouraged also to engage in authoritative parenting practices with their child [23]. Given that authoritative parenting practices have been strongly linked to healthy child outcomes [24], the presence of this recommendation in the program makes it unclear whether child outcomes are related to earlier sleep routines.

In a study examining mother and infant cortisol levels during a sleep training program, participation was associated with cessation of infant crying when transitioning to sleep—supporting the successfulness of this approach to extinguishing infant signaling. Associated with this cessation of crying was a decrease in maternal cortisol levels. However, there was not a corollary decrease in infants' cortisol levels across the residential program [25]. As this research did not examine cortisol levels around sleep following program completion, the long-term implications of these findings are not known.

1.1. Focusing on responsiveness

To address questions about infant sleep patterns, parent support, care presence, and behavioral modification approaches to increase infant TST and crying, this research examines the role of responsiveness to infants during their transitions to sleep. This research explores whether a response-based sleep intervention increases infant TST without limiting parent presence or use of a behavioral sleep program focused on extinguishing infant crying during sleep.

Overall, responsiveness to infant signals has been established as important to their development and well-being [26,27,28]. This is evidenced in research examining the role of emotional responsivity in infant development. Emotional responsivity, which entails expressing as well as responding to emotional signals of another individual, has been identified as crucial to the attachment relationship [29] and, ultimately, important in the development of a child's autonomy. Feldman [17] discussed the concept of synchrony, a related concept which refers to the biologically driven rhythmic nature of the parental response to infant signals and infant response to parental care. Through continuing action and response, the parent-infant pair develops a relationship that assists the growing child in developing self-regulation and positive social relationships [30].

A lack of response to infant cries at night or being inconsistent in responding between day and night signals for care may lead to increased infant stress [31] with caregiver responsiveness necessary to help infants self-regulate their physical and emotional responses to stress [28]. This view is supported by research in which there was an increase in autonomic system arousal in neonates during episodes of maternal separation [32]. These researchers suggested that the infant who received more attention at night may have more external emotional regulation assistance than those who sleep alone at night and do not receive as much nocturnal attention [32]. This would suggest that infant emotional needs continue through the night and responding to infant signaling encourages the development of self-regulation by infants.

In research examining infant sleep and mothers' emotional availability, Teti and colleagues [33] forward emotional availability as an important part of bedtime practices. Specifically, mothers' emotional availability was related to fewer infant night wakings and fewer times mothers had to return to their infants at bedtime [33]. Mothers' emotional availability was inversely related to their rating of whether infants had sleep difficulties [33].

A number of reviews have considered the relationship between maternal mood and infant sleep [10,34]. For example, changes in maternal sleep physiology and related fatigue can contribute to maternal depression during the postpartum period [10,34]. As the symptoms associated with depression may impact the perceived emotional availability of the mother, the maternal responsiveness observed to help alleviate infant sleep disruptions may not be as prevalent. Though an association has been observed between the depressive symptomatology of the mother and infant sleep, the causations of maternal depression and infant sleep

behaviors have not been clearly identified to what is a causative factor and what is a resulting factor in infant sleep disturbances [10,35].

1.2. Current study

This research provides the first empirical examination of the effectiveness of a non-behaviorally based sleep intervention in increasing infant TST through mother-infant participation in a response-based sleep program. By examining both infant TST and maternal and infant physiological markers of stress during a sleep intervention, this research will be helpful in informing current debates regarding infant sleep practices and parent responsiveness.

1.3. Hypotheses

1.3.1. Mothers' and infants' participation in a response-based, residential sleep intervention will increase infant TST from Pre-Admission to Days 1, 2, and 3 of the program intervention and nine days after program completion.

1.3.2. Infant TST will increase from Pre-Admission to Days 1, 2, and 3 of the program intervention and nine days after program completion for mothers reporting significant levels of depression, anxiety, or stress.

1.3.3. Participation in the response-based residential sleep intervention will be associated with decreases in infant and maternal cortisol levels from Pre-Admission to nine days after program completion.

2. Methods

2.1. Study context

Changes in infant TST and maternal and infant levels of cortisol were examined across four time points during attendance in a residential sleep intervention program and at one time point after mothers and infants completed the program and returned home (scheduled for the first weekend night of the second week at home to accommodate completion of the sleep log and saliva sampling). At each time point, cortisol levels were assessed at wake, initiation of infant sleep routine, and 20 min after infants transitioned to sleep. Infant TST and cortisol levels were examined across mothers' self-reported levels of depression, anxiety, and stress. The intervention at the participating facility provided a 5-day/4-night intervention program for mothers who reported their infants as exhibiting significant sleep problems defined as multiple overnight wakings, infant distress at day and night sleep settling times, and a history of extended settling periods.

2.2. Study population

Participants were 34 mother-infant dyads (Mother $M_{age} = 32.59$, range 23–41 years; infant $M_{age} = 7.16$ months, age range 4–11 months; 16 males) who were admitted to a public residential family-care facility in an urban area in Australia. Demographic data were available from 23 of the participating mothers. Based on this data, 17 mothers reported being born in Australia. Other reported countries of birth included New Zealand, India, United States, South Africa, Malaysia, and the United Kingdom, with 1 participant from each country. 22 mothers reported currently having a partner with partnership status either legally married ($n = 19$) or defacto relationship ($n = 3$). One mother reported being divorced or my marriage has dissolved. The target child was the only child for 15 mothers and 8 mothers reported the infant to be their second child. Mothers' education level ranged from secondary school before Year 12 ($n = 1$), Year 12 ($n = 2$), University Certificate ($n = 6$), Bachelors ($n = 6$), Graduate Diploma ($n = 1$), Masters ($n = 6$), and Doctorate ($n = 1$). Mothers' reported total family income (in Australian dollars) from \$15,000 to \$30,000 ($n = 2$), \$30,000 to \$50,000 ($n = 2$), \$50,000 to \$70,000 ($n = 3$), \$70,000 to \$100,000 ($n = 6$), and \$100,000+ ($n = 7$).

2.3. Procedures

2.3.1. Recruitment

All mothers with infants between 4 and 10 months of age referred to the residential program were advised of the study prior to admission to the residential center. 64 mothers were invited to participate. Of these mothers, 54 (84%) agreed to participate in the study with their infant. Of these 54 mothers, 20 (37%) withdrew during their participation. Fifteen mothers withdrew because they feared cortisol collection following infants' transition to sleep would wake their infant; 1 withdrew as engaging in the sleep program and study was too much pressure, 1 withdrew based on mental health concerns, and the reason for withdrawing for 1 mother was unknown.

Upon arrival, mothers eligible to participate were provided with information regarding the research and those choosing to participate signed an informed consent. The project had ethics approval from the Human Research Ethics Committee Mercy Health, Melbourne, Australia, the health facility human ethics committee, as well as the respective academic institutions of each researcher. All participating mothers were assured verbally and in writing that there was no penalty for choosing not to engage in the study. Mothers were assured that they may withdraw from the study at any time. Mothers who smoked, were on prescription antidepressant medication, or steroid based anti-inflammatory medication were excluded from the study, as these alter salivary cortisol. To ensure consistency of information provided to mothers, the registered nurses on the admission shifts were the only responsible parties for determining whether or not the dyads fit the criteria and alerting the researcher of the mother's interest and location.

2.3.2. Recording sleep hours

During the residential intervention program, Maternal and Child Health nurses and qualified early childhood workers together with the infants' mothers maintained the wake and sleep log on program Days 1, 2, and 3 of the residential intervention. Mothers recorded hours of wake and sleep time in their homes for a 24-hour period nine days after intervention completion. At admission and following consent to participate in the study, mothers were asked to respectively log infant hours of sleep across the two days immediately prior to admission.

2.3.3. Intervention

The residential program incorporates education on normative sleep patterns, including night wakings, in an effort to move parents toward considering the infant's need of emotional and physical nutrition when transitioning to sleep. Emphasis is placed on the needs of infants to have access to parental care during this time and the importance of contingently responsive care to the infant cues and behaviors, both day and night. During the period of infant settling, parents are encouraged to provide progressively increasing parental care, based on the infant cues and behaviors.

This care starts with parents watching for and responding to infant sleep signs. Parents are encouraged to develop consistent sleep preparation that includes a predictable set of events that can be replicated once home, such as quiet time before sleep, which includes direct physical contact with the parent including book reading and or massage. Infant needs at the time of separation for sleep are discussed, including the need for parental emotional availability during this period.

Parents are encouraged to listen to the infant and offer care in response to infants' communication. This guides parents away from either intrusive or non-contingent care. In the event infants cry, parents are coached to respond with low level support care and build it over a short period of time, e.g., no longer than 15 to 30 seconds. This low level of supportive care can include quiet verbal comforting, stroking the infant, patting the mattress, or other low level calming responses. During this short length of time, parents have the opportunity to watch and listen for cues, and the infant has the opportunity to self-regulate.

Parents are advised that it is important that the infant is not left to cry. If soothing without picking up their infant does not calm the infant, parents are encouraged to provide increasing levels of response and attention until they can soothe their infant, which includes cuddling or feeding to comfort. When responding to their infants' waking overnight, parents are encouraged to tune into the infants' communication before intervening and are encouraged to observe for and respond to infant cues and behavior. This type of attending and responding over time provides both parent and infant predictability of contingent parental response to infant cues. This ensures the infant is not left to cry but rather is offered comforting when unable to calm. By encouraging the parent to offer contingent care, tired parents experience how the cues of the infant lead the care which ultimately results in calm sleep transitioning and longer sleep hours. This cue based care ensures each individual's communication and capacity is factored into the care planning.

This development of synchrony of parental attention and response to infant communication in the form of cues and behavior is encouraged and guided by the facility nursing staff. The residential center policy promotes 'care by parent' whereby staff guide and support parents in watching for and thinking about both the communication of their infant and their responses to their infants' signals. Promotion of mothers' capacity to look at and listen to their infants and respect infant experiences is an integral component of the intervention.

2.4. Instruments and measures

2.4.1. Demographic background information

After consenting, mothers completed a demographic questionnaire; information for 23 mothers was available for reporting at the time of analyses. Information for the remaining participants was not completed.

2.4.2. Infant TST

The sleep log [36] used at the facility to track sleep and wake behaviors provided the measure of infant TST prior to admission, during Days 1, 2, and 3 of the intervention, and at the ninth day after mothers and infants returned home. The sleep log provides an efficient way to track sleep and wake times and has been used in a number of trials to date [36]. On Days 1, 2, and 3, the sleep log was maintained by the Centre staff and mothers. Mothers completed the sleep log for the home assessment following program completion. Mother reports of infant TST on the two days prior to admission were collected retrospectively following mothers' admission and consent to participate in the research project.

2.4.3. Edinburgh Postnatal Depression Scale (EPDS)

The EPDS is a self-rating scale originally designed to help identify risk of postnatal depression [37]. This validated tool [38,39,40] is used in a range of perinatal disciplines to screen for antenatal and postnatal evidence of depressive symptoms [41]. In this study, the EPDS was completed by the consenting mother at, or close to, admission. Mothers were identified as at probable risk of depression when scores were ≥ 13 [42,43].

2.4.4. Depression, Anxiety, and Stress Scale 21 (DASS-21)

The DASS-21 [44,45,46] is a self-administered instrument measuring the intensity of risk of depressive, anxiety and stress symptoms [46,40] with the scoring categories relating to the intensity of the symptoms. DASS-21 cut-off scores for severe or extremely severe levels of symptomatology for depression, anxiety, or stress were ≥ 21 for depression, ≥ 15 for anxiety, and ≥ 26 for stress. DASS-21 cut-off scores for moderate or greater levels of symptomatology for depression, anxiety, or stress were ≥ 14 for depression, ≥ 10 for anxiety, and ≥ 19 for stress.

2.4.5. Salivary cortisol levels

Maternal and infant salivary cortisol was assessed at three time points (wake, initiation of infant nighttime sleep routine, and 20-minutes after infants had transitioned to sleep) during each of the program

days and on the ninth day after their return home. Mothers donated 2 ml of saliva into the appropriate pathology tube, while infant saliva was collected via sorbette. All samples were frozen in a dedicated, monitored freezer until collection and transport frozen in a laboratory supplied truck to the pathology laboratory. Home samples were stored in freezers and transported in thermo-regulated containers to assure samples remained frozen until reaching the laboratory. Salivary cortisol samples were assayed using a highly-sensitive enzyme immunoassay (Salimetrics, State College, PA). The test used 25 μ l of saliva, had a lower limit of sensitivity of 0.007 μ g/dl, and a range of sensitivity from 0.007 to 3.0 μ g/dl [average intra- and inter-assay coefficients of variation of <10% and 15%, respectively]. Outliers were identified as individual scores that exceeded their respective means by at least 3 standard deviations. Salivary assays were completed at Salivary Laboratory, Stratch Scientific, Inc., APAC Pty, Ltd., Sydney, Australia.

2.5. Preliminary analyses

A multiple imputation method was conducted to impute missing values for variables in the dataset. These values are assumed to be missing at random and averages were pooled to estimate missing data points. To determine the association between mothers' measures of depression and other measures of well-being, correlational analyses were computed. Mothers' DASS-21 scores were significantly positively correlated with mothers' EPDS scores ($r = 0.72$, $r = 0.61$, and $r = 0.62$ for DASS-21 depression, anxiety, and stress scores, respectively).

3. Results

3.1. Infant TST

Based on assessment of TST reported in the sleep logs by mothers (Pre-Admission and Home assessment times) and nurses (Days 1–3 assessment times), infant TST after return Home was significantly higher than at Pre-Admission ($t(59) = 8.96$, $p < 0.001$; Fig. 1). During Days 1 through 3 of the residential program, infant TST significantly increased from Day 1 to Day 2 ($t(510) = 3.12$, $p = 0.002$), Day 2 to Day 3 ($t(345) = 5.97$, $p < 0.001$), and Day 3 to Home ($t(581) = 4.20$, $p < 0.001$) (Fig. 1). Hypothesis 1.3.1 was supported.

3.2. EPDS

3.2.1. EPDS and change in infant TST

Mothers' EPDS scores ranged from 5 to 22 ($M = 15.1$). Change in infant TST was compared between those mothers who scored at or above the symptomatic cutoff score of 13 ($n = 26$, 76%) and those who scored

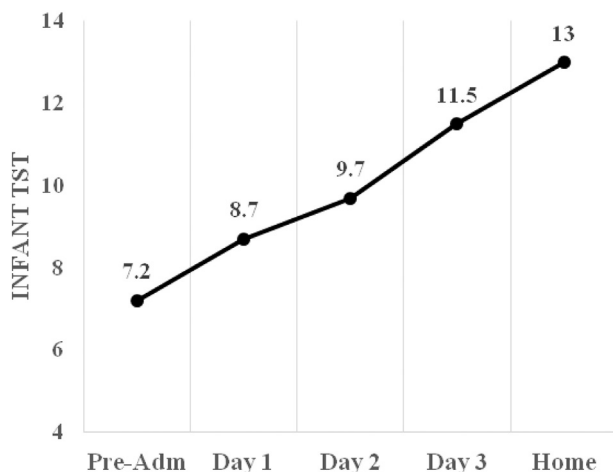


Fig. 1. Infant total sleep time (TST) per day from preadmission to home report. ($n = 34$).

below 13 ($n = 8$). A repeated measures analysis of variance (ANOVA) identified a significant effect of program participation on infant TST both for infants whose mothers scored above ($F(4,22) = 33.38$, $p < 0.001$, $\eta_p^2 = 0.57$) and infants whose mothers scored below ($F(4,4) = 19.63$, $p < 0.001$, $\eta_p^2 = 0.73$) the cutoff score of 13. Greenhouse-Geisser analyses were reported to adjust for a violation of sphericity. Paired-sample t -tests computed to determine direction of effect of program participation on infant TST from Pre-Admission to Home hours found infant TST was significantly higher after return Home than Pre-Admission for both infants whose mothers scored above ($t(46) = 7.14$, $p < 0.001$) and infants whose mothers scored below ($t(91) = 5.86$, $p = 0.001$) the cutoff score.

Paired sample t -tests were computed to examine significance of mean difference in infant TST across the days of program participation. For mothers scoring above the cutoff score for severe or very severe depression, infant TST increased significantly from Day 1 to Day 2 ($t(2863) = 2.65$, $p = 0.01$), Day 2 to Day 3 ($t(2222) = 4.83$, $p < 0.001$), and Day 3 to Home ($t(338) = 3.01$, $p = 0.005$) (Table 1). For mothers scoring below the cutoff score for depression, infant TST increased significantly between Day 2 to Day 3 ($t(132) = 5.96$, $p = 0.0001$) and Day 3 to Home ($t(59) = 3.19$, $p = 0.01$) (Table 1). Hypothesis 1.3.1 was supported.

3.2.2. TST across EPDS symptomatology

For each day of participation, i.e., Pre-Admission, program Days 1–3, and Home, infant TST was compared between infants whose mothers scored above and infants whose mothers scored below the cutoff score of 13. No significant differences in TST were identified on any of the days.

3.2.3. EPDS prediction of change in TST

Mothers' EPDS score at intake did not explain variance in infant sleep hours at Pre-Admission, program days, or Home measures based on ANOVAs computed at each time point.

3.3. DASS-21 depression

3.3.1. Severe symptomatology for depression

Mothers' DASS-21 depression scores ranged from 4 to 24 ($M = 14.2$) with 17% ($n = 6$) scoring at or above the symptomatic depression cutoff score of 21 indicating severe to very severe symptomatology for depression. A repeated measures analysis of variance (ANOVA) identified a significant effect of program participation on infant TST both for infants whose mothers scored above ($F(4,2) = 12.26$, $p = 0.01$, $\eta_p^2 = 0.68$) and infants whose mothers scored below ($F(4,3) = 41.34$, $p < 0.001$, $\eta_p^2 = 0.60$) the cutoff score of 21. Greenhouse-Geisser analyses were reported to adjust for a violation of sphericity. Paired-sample t -tests computed to determine direction of effect of program participation on infant TST from Pre-Admission to Home hours found infant TST was significantly higher after return Home than Pre-Admission for both infants whose mothers scored above ($t(40) = 3.38$, $p = 0.002$) and mothers who scored below ($t(68) = 8.26$, $p < 0.001$) the cutoff score of 21 (Table 1).

Paired sample t -tests were computed to examine significance of mean difference in infant TST across each of the days of program participation. For mothers whose scores indicated severe or very severe depression, infant TST significantly increased from Day 1 to Day 2 ($t(5) = 4.57$, $p < 0.001$) and Day 2 to Day 3 ($t(5) = 3.08$, $p = 0.002$). For mothers whose scores did not indicate symptomatology, infant TST significantly increased from Day 1 to Day 2 ($t(505) = 2.63$, $p = 0.009$), Day 2 to Day 3 ($t(301) = 5.53$, $p < 0.001$), and Day 3 to Home ($t(393) = 3.80$, $p < 0.001$) (Table 1; Fig. 2). Hypothesis 1.3.1 was supported.

3.3.2. TST across DASS-21 depression scores

For each day of participation, i.e., Pre-Admission, program Days 1–3, and Home, infant TST was compared between infants whose mothers scored above and infants whose mothers scored below the cutoff

Table 1
 Infant Total Sleep Time across mothers scoring above or below the EPDS and DASS-21 severe cutoff scores.

	Pre-Adm	Day 1	Day 2	Day 3	Home	Pre-Adm–Home
All infants	7.2 (2.9)	8.7 (2.0)*	9.7 (1.8)**	11.5 (1.9)***	13.0 (1.8)***	7.2–13.0***
EPDS						
Severe–very severe	7.5 (0.69)	8.8 (0.40)	9.8 (0.39)**	11.6 (0.40)***	12.8 (0.40)***	7.5–12.8***
Not severe	6.2 (1.08)	8.2 (0.82)	9.2 (0.49)***	11.2 (0.61)***	13.4 (0.59)**	6.2–13.4 ^a
DASS-21 depression						
Severe–very severe	5.8 (1.50)	8.3 (0.61)	9.2 (0.53)***	10.3 (0.79)**	11.3 (0.99)	5.8–11.3**
Not severe	7.5 (0.62)	8.8 (0.42)	9.8 (0.38)**	11.7 (0.35)***	13.3 (0.32)***	7.4–13.3***
DASS-21 anxiety						
Severe–very severe	6.7 (0.88)	8.6 (0.42)*	10.0 (0.46)***	11.9 (0.50)***	12.9 (0.52)	6.8–12.9***
Not severe	7.6 (0.76)	8.8 (0.60)	9.3 (0.45)	11.1 (0.43)***	13.0 (0.43)***	7.6–13.0***
DASS-21 anxiety						
Severe–very severe	6.9 (1.60)	8.9 (0.66)	9.9 (0.65)***	10.9 (0.83)*	11.9 (0.85)	0.9–11.9**
Not severe	7.3 (0.60)	8.6 (0.43)	9.6 (0.34)*	11.7 (0.36)***	13.3 (0.35)***	7.2 (13.3)***

Note. EPDS Severe symptomatology (≥ 13); DASS-21 Depression Severe symptomatology (≥ 21); DASS-21 Anxiety Severe symptomatology (≥ 15); DASS-21 Stress Severe symptomatology (≥ 26).

^a = approached significance.
 * $p \leq .05$.
 ** $p \leq .01$.
 *** $p \leq .001$.

score of 21. Based on independent-samples *t*-tests, infant TST was significantly different only for infants' Home TST. Home TST was significantly lower for infants whose mothers' scores indicated severe or very severe symptomatology in comparison to infants whose mothers' scores did not indicate severe or very severe symptomatology ($t(160) = 2.58, p = 0.01$). Hours of sleep between infants whose mothers scored above or below the cutoff score of 21 were not significantly different at Pre-Admission or program Days 1–3.

3.3.3. Moderate symptomatology for DASS-21 depression

Analyses were completed to examine infant TST when a cutoff score indicating moderate symptomatology was used. These analyses compared effect of program participation on infant TST for infants whose mothers scored at or above the DASS-21 cutoff score of 14 (61%, $n = 21$). A repeated measures ANOVA identified a significant effect of program participation on infant TST both for infants whose mothers scored above ($F(4,3) = 32.14, p < 0.001, \eta_p^2 = 0.61$) and infants whose mothers scored below ($F(4,4) = 19.25, p < 0.001, \eta_p^2 = 0.61$) this cutoff point for moderate symptomatology. Greenhouse-Geisser analyses were reported to adjust for a violation of sphericity. Paired-sample *t*-tests computed to determine direction of difference in TST from Pre-Admission to Home hours found infant TST was significantly higher after return Home than at Pre-Admission for both infants whose mothers scored above ($t(73)$

$= 7.42, p < 0.001$) and mothers who scored below ($t(72) = 5.33, p < 0.001$) the cutoff score.

Paired sample *t*-tests computed to examine significance of mean difference in infant TST across the days of program participation. For mothers whose scores indicated moderate or higher symptomatology for depression, infant TST significantly increased from Day 1 to Day 2 ($t(1369) = 2.17, p = 0.03$), Day 2 to Day 3 ($t(1029) = 4.14, p \leq 0.001$), and Day 3 to Home ($t(187) = 3.69, p < 0.001$) (Table 2). For mothers whose scores indicated moderate to no symptomatology, infant TST significantly increased from Day 1 to Day 2 ($t(410) = 2.25, p = 0.03$) and Day 2 to Day 3 ($t(232) = 4.53, p < 0.001$) (Table 2).

3.4. DASS-21 anxiety

3.4.1. Severe symptomatology for anxiety

Maternal DASS-21 anxiety scores ranged from 2 to 24 ($M = 13.4$) with 50% ($n = 17$) scoring at or above the symptomatic anxiety cutoff score of 15 indicating severe to very severe symptomatology for anxiety. A repeated measures ANOVA identified a significant effect of program participation on infant TST both for infants whose mothers scored above ($F(4,13) = 32.22, p = 0.01, \eta_p^2 = 0.66$) and infants whose mothers scored below ($F(4,13) = 32.23, p < 0.001, \eta_p^2 = 0.66$) the cutoff score of 15. Greenhouse-Geisser analyses were reported to adjust for a violation of sphericity. Paired-sample *t*-tests computed to determine effect of program participation on infant TST from Pre-Admission to Home hours found infant TST was significantly higher after return Home than at Pre-Admission for both infants whose mothers scored above ($t(62) = 6.84, p < 0.001$) and mothers who scored below ($t(98) = 6.07, p = 0.01$) the cutoff score of 15.

Paired sample *t*-tests were computed to examine significance of mean difference in infant TST across the days of program participation. For mothers scoring above the cutoff score for severe or very severe anxiety, infant TST significantly increased from Pre-Admission to Day 1 ($t(32) = 2.14, p = 0.04$), Day 1 to Day 2 ($t(860) = 3.40, p = 0.001$), and Day 2 to Day 3 ($t(483) = 4.87, p < 0.001$) (Table 1). For mothers whose scores indicated symptomatology below the severe cutoff score, infant TST significantly increased from Day 2 to Day 3 ($t(552) = 3.74, p = 0.001$) and Day 3 to Home ($t(265) = 4.42, p = 0.001$) (Table 1). Hypothesis 1.3.1 was supported.

3.4.2. TST across DASS-21 anxiety scores

For each day of participation, i.e., Pre-Admission, program Days 1–3, and Home, infant TST was compared between infants whose mothers scored above and infants whose mothers scored below the cutoff

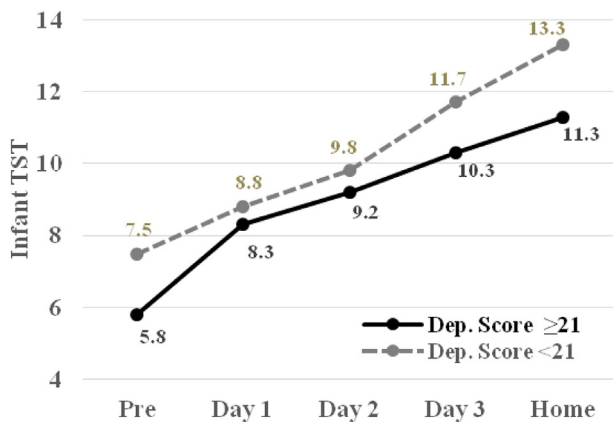


Fig. 2. Hours of infant sleep for infants whose mothers' DASS-21 scores indicated presence of severe and extremely severe symptomatology for depression and mothers whose scores did not indicate this level of symptomatology. Infants total sleep time (TST) was significantly different at the Home sleep.

Table 2
Infant Total Sleep Time across mothers scoring above or below the DASS-2.

	Pre-Adm	Day 1	Day 2	Day 3	Home	Pre-Adm – Home
DASS21 Depression						
Moderate or above	7.5 (0.70)	8.9 (0.45)	9.8 (0.40)*	11.3 (0.40)***	13.1 (0.48)***	7.5–13.1***
Below moderate cutoff	6.6 (0.98)	8.2 (0.61)	9.5 (0.56)*	11.7 (0.60)***	12.8 (0.46)	6.6–12.8
DASS21 anxiety						
Moderate to very severe	7.1 (0.71)	8.7 (0.45)*	9.9 (0.39)**	11.7 (0.43)***	13.2 (0.44)**	7.1–13.2***
Below Moderate cutoff	7.4 (1.03)	8.6 (0.61)	9.1 (0.58)	10.9 (0.44)***	12.5 (0.44)**	7.4–12.5**
DASS21 stress						
Moderate to very severe	7.5 (0.76)	8.9 (0.41)	9.9 (0.44)***	11.5 (0.44)***	12.5 (0.44)**	7.5–12.9**
Below moderate cutoff	6.8 (0.86)	8.4 (0.65)	9.4 (0.49)	11.5 (0.53)***	13.0 (0.48)**	6.8–13.0***

Moderate cutoff scores.

Note. DASS-21 Depression Moderate symptomatology (≥ 14); DASS-21 Anxiety Moderate symptomatology (≥ 10); DASS-21 Stress Moderate symptomatology (≥ 19).* $p \leq 0.05$.** $p \leq 0.01$.*** $p \leq 0.001$.

score of 15. No significant differences in TST were identified based on independent-samples t -tests.

3.4.3. Moderate symptomatology for anxiety

Analyses were completed to examine infant TST when a cutoff score indicating moderate symptomatology was used. These analyses compared effect of program participation on infant TST for infants whose mothers (71%, $n = 24$) scored at or above the cutoff score of 10. A repeated measures ANOVA identified a significant effect of program participation on infant TST both for infants whose mothers scored above ($F(4,2) = 38.70, p < 0.001, \eta_p^2 = 0.63$) and infants whose mothers scored below ($F(4,6) = 12.20, p < 0.001, \eta_p^2 = 0.57$) this cutoff point for moderate symptomatology. Greenhouse-Geisser analyses were reported to adjust for a violation of sphericity. Paired-sample t -tests computed to determine direction of difference in TST from Pre-Admission to Home hours found infant TST was significantly higher after return Home than infant TST at Pre-Admission for both infants whose mothers scored above ($t(53) = 8.02, p < 0.001$) and mothers who scored below ($t(286) = 4.36, p < 0.001$) the cutoff score of 10 (Table 2).

Paired sample t -tests were computed to examine significance of mean difference in infant TST across each of the days of program participation. For mothers scoring at or above the cutoff score for moderate symptomatology for anxiety, infant TST significantly increased from Pre-Admission to Day 1 ($t(46) = 2.08, p = 0.04$), Day 1 to Day 2 ($t(1690) = 3.32, p = 0.001$), Day 2 to Day 3 ($t(2075) = 4.65, p < 0.001$), and Day 3 to Home ($t(250) = 3.13, p = 0.02$) (Table 2). For mothers scored below the cutoff score, infant TST increased from Day 2 to Day 3 ($t(58) = 4.13, p < 0.0001$) and Day 3 to Home ($t(95) = 2.78, p = 0.007$) (Table 2). Hypothesis 1.3.2 regarding infant TST and mothers' DASS-21 anxiety scores was supported.

3.5. DASS-21 stress

3.5.1. Severe symptomatology for stress

Mothers' DASS-21 stress scores ranged from 1 to 33 ($M = 19.4$) with 24% ($n = 8$) scoring at or above the DASS-21 stress cutoff score of 26, indicating severe to very severe symptomatology for stress. A repeated measures ANOVA identified a significant effect of program participation on infant TST both for infants whose mothers scored above ($F(4,4) =$

Table 3
Mother DASS-21 depression, anxiety, and stress scores at admission as related to infant TST following program completion.

DASS-21	B	SE	Beta	t	p
Anxiety	−0.017	0.039	−0.486	2.473	0.02
Depression	−0.052	0.033	0.513	−2.018	0.05
Stress	0.083	0.029	0.117	0.545	0.59

Note. $n = 34$.

9.73, $p < 0.001, \eta_p^2 = 0.56$) and infants whose mothers scored below ($F(4,22) = 43.09, p < 0.001, \eta_p^2 = 0.63$) the cutoff score of 26. Greenhouse-Geisser analyses were reported to adjust for a violation of sphericity. Paired-sample t -tests computed to determine direction of effect of program participation on infant TST from Pre-Admission to Home hours found infant TST was significantly higher after return Home than Pre-Admission for both infants whose mothers scored above ($t(32) = 3.27, p < 0.001$) and infants whose mothers scored below ($t(73) = 8.50, p < 0.001$) the cutoff score of 26 (Table 1).

Paired sample t -tests were computed to examine significance of mean difference in infant TST across each of the days of program participation. For mothers whose scores indicated severe or very severe stress, infant TST increased from Day 1 to Day 2 ($t(7) = 6.11, p < 0.001$) and Day 2 to Day 3 ($t(7) = 2.38, p = 0.02$) (Table 1). For mothers whose scores did not indicate symptomatology, infant TST increased between Day 1 to Day 2 ($t(506) = 2.40, p = 0.02$), Day 2 to Day 3 ($t(249) = 5.71, p < 0.001$), and Day 3 to Home ($t(219) = 3.78, p < 0.001$) (Table 1). Hypothesis 1.3.1 was supported.

3.5.2. TST across DASS-21 stress scores

For each day of participation, i.e., Pre-Admission, program Days 1–3, and Home, infant TST was compared between infants whose mothers scored above and infants whose mothers scored below the cutoff score of 26. Based on independent-samples t -tests, infant TST was not significantly different between these groups of infants on any of these program days.

3.5.3. Moderate symptomatology for stress

Analyses were completed to examine infant TST when a cutoff score indicating moderate symptomatology was used. These analyses compared effect of program participation on infant TST for infants whose mothers (56%, $n = 19$) scored at or above the cutoff score of 19 indicating moderate to very severe symptomatology for stress. A repeated measures ANOVA identified a significant effect of program participation on infant TST both for infants whose mothers scored above ($F(4,15) = 31.18, p = 0.01, \eta_p^2 = 0.64$) and infants whose mothers scored below ($F(4,11) = 19.93, p < 0.001, \eta_p^2 = 0.59$) this cutoff point for moderate symptomatology. Greenhouse-Geisser analyses were reported to adjust for a violation of sphericity. Paired-sample t -tests computed to

Table 4
Mothers' cortisol levels at each collection time across intervention and home samples.*

	Day 1	Day 2	Day 3	Home
Wake		−1.26 (0.55)	−1.04 (0.62)	−1.56 (0.69)
Presleep	−2.51 (0.53) ^{Day4*}	−2.64 (0.63)	−2.52 (0.50)	−2.88 (0.68) ^{Day1*}
Postsleep	−2.86 (0.53)	−2.78 (0.92)	−2.89 (0.61)	−2.87 (0.69)

Note. $n = 34$.* $p < 0.05$.^{Day*} indicates significant change between days indicated.

Table 5
Infants' cortisol levels at each collection time across intervention and home samples.

	Day 1	Day 2	Day 3	Home
Wake		−1.15	−1.16	−1.43
Presleep	−2.40	−2.19	−2.35	−2.30
Postsleep	−2.44 ^{Day2*}	−1.68 ^{Day1*,Day4**}	−1.95 ^{Day4*}	−2.83 ^{Day2**,Day3*}

Note. $n = 34$.

* $p < 0.05$.

^{Day*} indicates significant change between days indicated.

determine direction of effect in TST from Pre-Admission to Home hours found infant TST was significantly higher after return Home than at Pre-Admission for both infants whose mothers scored above ($t(68) = 6.90$, $p < 0.001$) and those who scored below ($t(108) = 6.10$, $p < 0.001$) the cutoff score of 19 (Table 2).

Paired sample t -tests were computed to examine significance of mean difference in infant TST across each of the days of program participation. For mothers who scored above the cutoff score, infant TST increased from Day 1 to Day 2 ($t(352) = 3.42$, $p = 0.001$), Day 2 to Day 3 ($t(437) = 4.84$, $p < 0.001$), and Day 3 to Home ($t(312) = 3.08$, $p = 0.002$) (Table 2). For mothers who scored below the cutoff, infant TST increased from Day 2 to Day 3 ($t(553) = 3.86$, $p < 0.001$) and Day 3 to Home ($t(287) = 2.69$, $p = 0.008$) (Table 2). Hypothesis 1.3.2 regarding infants' TST and mothers' DASS-21 stress scores was supported.

3.6. DASS-21 scores and infant TST

Linear regression models were computed to determine whether mothers' DASS-21 scores at intake predicted infants' hours of sleep reported at preadmission; intervention Days 1, 2, or 3; or at the Home assessment. Based on these analyses, mothers' DASS-21 depression and anxiety scores predicted infants' total sleep time at Day 3 (Table 3).

3.7. Mother and infant cortisol levels

Paired samples t -tests were computed to examine changes in mothers' and infants' cortisol levels at wake, at the beginning of the nighttime sleep routine, and 20-minutes after infants transitioned to sleep (Tables 4 and 5; Fig. 3). The hypothesis that cortisol levels would decrease from the beginning of the intervention through salivary samples at Home collection time was supported for mothers at presleep. Mothers' cortisol levels on Day 1 presleep were significantly higher than at the presleep home measure ($t = 2.18$, $p = 0.038$). No significant

differences were found between mothers' cortisol levels at wake or postsleep samples.

Based on paired samples t -tests, infants' cortisol levels at the presleep collection were significantly higher at the Day 2 in comparison to the Home measure ($t = 2.01$, $p = 0.05$). Infants' cortisol levels at the postsleep collection were significantly higher at the Day 3 in comparison to the Home measure ($t = 2.39$, $p = 0.03$). Infants' cortisol levels were significantly lower on Day 1 postsleep in relation to Day 2 postsleep levels ($t = 2.72$, $p = 0.01$).

4. Discussion

Teaching parents to understand and respond to infant cues, through the day and at transitions to sleep, was associated with an increase in infants' TST in mothers identifying their infants' sleep schedules as problematic prior to their participation in a response based sleep intervention. The changes in infant sleep time across mothers experiencing depression, anxiety, and stress further support response-based intervention as a viable approach to supporting parents in helping their infants sleep. Of particular importance in regard to infant sleep research and practice is the finding that infants' sleep time can be increased without engaging in behavioral extinction programs necessitating parental nonresponse to infant cues. This research provides, to the knowledge of the authors, the first empirically supported examination of response-based sleeping interventions to increase infant sleep. In addition to longer sleep time, a primary goal of many sleep interventions, the intervention focuses on responsiveness. The importance of reading infants' cues in a synchronous manner is clearly supported throughout developmental literature. Thus, the benefit of this approach in comparison to interventions that necessitate parental nonresponse to infant cues, is theoretically important [19,20,22]. These findings provide information important for both clinicians and parents.

In relation to parents, research continues to identify behaviorally based, parent-absent sleep interventions to be difficult for parents [13]. As the fundamental need for infants is responsiveness, even during the transition to sleep time, we aim to provide parents a means of responding to infants at sleep settling and waking times without negatively impacting infant sleep patterns and stress indicators. This educational intervention involves providing parents with an approach that incorporates their instincts to comfort distressed infants [47].

The potential benefit of focusing on infant cues rather than parental absence when infants transition to sleep is twofold. First, this approach provides parents with an approach to changing infant sleep patterns without the necessity of limiting responsiveness or being absent when infants transition to sleep. Thus, this approach can reduce the need for behavioral interventions requiring parental absence, resulting in a greater parent infant synchrony. Second, by focusing on recognition of infant cues, this intervention supports parents across settings. Parents become aware of infant cues regarding not only sleepiness but also hunger, distress, or other circumstances. This is likely to have additional benefits such as potentially impacting on parent-child interactions and attachment into the future.

Equally important to these two outcomes, this approach to helping parents adjust infant sleep patterns offers the infant an experience of parental comfort during the transition to sleep through the parent responding to the infant cues and behaviors. Research continues to identify behaviorally based, parent-absent sleep interventions to be difficult for parents [13] and emotional availability as important to both mothers' and infants' sleep quality [33]. Given the nature of behavioral intervention, particularly the absolute importance of consistency, parents' difficulty with non-responding can have a negative impact on the infant sleep patterns and emotional wellbeing [12].

Patterns of increase in TST for infants across levels of mothers' depression and anxiety symptomatology are interesting to examine. In relation to depression, mothers experiencing depressive symptoms are less likely than other mothers to engage with their infants—whether

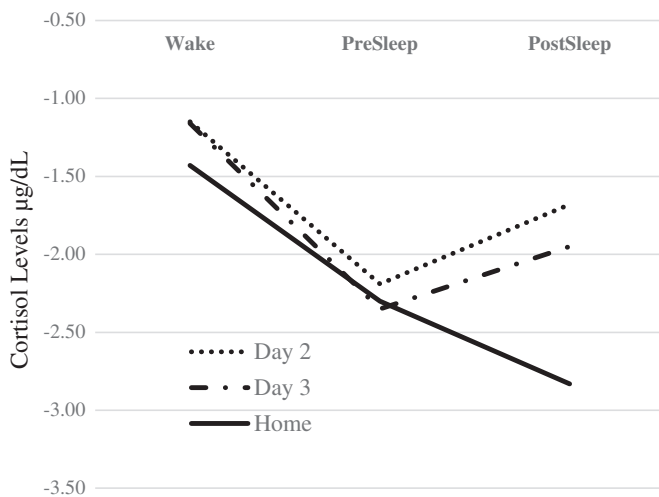


Fig. 3. Infant cortisol levels reported from wake, presleep, through postsleep for each program day. Note Day 1 is not shown as there was no wake cortisol sample for mothers and infants because Day 1 was an arrival day.

in response to their cues or synchrony of social interaction [48]. Reflecting the difficulty infants experience in engaging mothers experiencing depression, infants will often disengage from expectation for social interaction or synchronous response, noted as withdrawal [49]. In regard to infant sleep patterns, mothers who are exhibiting depression often have infants who sleep longer hours, perhaps associated with the lack of response from the mother [50]. Although infants whose mothers' DASS-21 scores indicate severe to very severe symptomatology have lower TSTs than other infants, the changes in TST across the program indicate some differences in these changes across program days. This is evident in that the only significant difference between infant TST within a program day is the Home measure of TST for these two groups of infants. At the Home measure of TST, infants whose mothers score above the cutoff for symptomatology sleep significantly fewer hours than infants whose mothers score below the cutoff (Fig. 3).

Changes in TST for infants of mothers with anxiety show a similar relation. Researchers have identified maternal anxiety as associated with fewer hours of TST for infants [51]. This association reflects the greater likelihood that mothers experiencing anxiety will wake infants while checking on them while they sleep or responding to modest movement of the infant during transitions across sleep states [52]. Changes in the TST of the infants whose mothers were anxious were greater at the initiation of the program than of the infants whose mothers' scores were not indicative of anxiety. However, the changes in TST were lower at the end of the program with both groups of infants exhibiting similar TST at program completion (Table 1).

Overall, this research provides evidence to support changes in infant sleep patterns based on building parents' awareness of the importance of responding to infant cues and behaviors. Education-based interventions encouraging the parent to be guided by the behavior of the infant, in order for timely care to be provided, requires the understanding that each parent-child dyad will have a unique experience at sleep time. This outcome was supported in the present research both regarding infants' TST during the program and at return home. With this outcome, parents are encouraged to offer infants care during the transition to sleep through the parent responding to infant cues and communication.

4.1. Limitations

A foreseeable limitation of the project design is the small sample size. This study is limited to presenting a first effort to study a response-based sleep intervention. The limited demographic information available to help delineate potential differences in changes in TST based on birth status, i.e., premature or full-term; breast or formula fed; single or multiples birth is a limitation in regard to generalizing the study results.

Whether mothers had a previous mental health diagnosis was not included as part of the inclusion/exclusion criteria, nor as a potential contributor to quality of infant sleep, unrelated to those identified during the program. Future research examining pre-natal factors associated with infant sleep quality, inclusive of mothers' mental health prior to and during pregnancy will be helpful in addressing these considerations.

Direct recruitment of participants at the time of admission to the sleep project did not provide for a randomly assigned group of participants. The study did not include a comparison group of mothers who declined participation, mothers who were currently prescribed antidepressant medication, or mothers with infants who were not identified as having sleep problems. The nature of recruitment and research design in follow-up studies will address these issues of design.

Conflict of interest

One author (HS) held a supervisory position at the Family Centre where the research was conducted. During the project period, HS had minimal contact with families during their participation in the program.

Notes or acknowledgements

There are a number of contributors without whom this work would not have been achieved. First and foremost, we thank the participants who agreed to contribute to research even though they were attending a parenting program due to other challenges. Their willingness to undertake additional research-related commitments was very generous and greatly appreciated. We thank the staff and management at the participating Melbourne-based Family Centre who embraced the research while also continuing to support families throughout the residential program. To the many research assistants and to those who supported funding distribution, we extend our thanks. We extend our thanks to Mercy Health, as well, for the support of this project.

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