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Effects of prone and supine positions on sleep state and stress responses in preterm infants

T. Jarus[a,1], O. Bart[b,*], G. Rabinovich[b], A. Sadeh[c], L. Bloch[b], T. Dolfin[d], I. Litmanovitz[d]

[a] *Department of Occupational Science and Occupational Therapy, CanDo Research Unit, Faculty of Medicine, University of British Columbia, Vancouver, Canada*
[b] *Department of Occupational Therapy, School of Allied Health, Medical Faculty, Tel Aviv University, Israel*
[c] *The Adler Center for Research in Child Development and Psychopathology, Department of Psychology, Tel Aviv University, Tel Aviv, Israel*
[d] *Department of Neonatology, Meir Medical Center, Kfar Saba, Israel Division of Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel*

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ABSTRACT

Aim: The purpose of the study is to assess the influence of prone or supine position on sleep states and on withdrawal and approach reactions of preterm infants.
Methods: Thirty-two preterm infants from Meir Medical Center, Israel, mean post menstrual age 30.37 ± 2.57, mean birth weight 1250 g ± 313.86, participated in the study. Infants were studied during 48 h. Positions (prone and supine) were alternated every 3–4 h after feedings. Sleep states were assessed by Actigraph measurement and by two daily 30-min Naturalistic Observations of Newborn Behavior (NONB) to confirm sleep states and for recording the behavioral reactions (approach and withdrawal).
Results: In the prone position there were more approach reactions as compared to withdrawal reactions ($p < .001$) while in the supine position, the approach and withdrawal reactions were comparable. In the prone position more sleep patterns (deep sleep, light sleep, drowsy) were observed as opposed to more awake patterns (quiet awake, active awake and agitated fussy) that were seen in the supine position.
Conclusions: Clinical implications encourage placing the preterm infant in the prone position while in the NICU. This enables important achievements such as longer periods of quality sleep, and production of adaptive self-regulatory reactions.

1. Introduction

In the Neonatal Intensive Care Units (NICU), preterm infants can be placed in different positions which have an impact on various aspects of the child's survival and development. Ariagno et al. (2003) assessed the influence of the preterm positions on their sleep and other medical factors, and found that in the supine position, the preterm infant exhibits more transitions between the 6 sleep states, thus experiencing more arousals during sleep. Other studies found that in the prone position, more quiet sleep and less awake states were detected in comparison to the supine position (Galland, Taylor, & Bolton, 2002; Grenier, Bigsby, Vergara & Lester, 2003; Masterson, Zucker, & Schultze, 1987; Myers et al., 1997). Also ventilated preterm infants slept better and exhibited less stress in the prone position (Chang, Anderson, & Lin, 2002). Goto et al. (1999) in their study found that more quiet sleep periods were observed in prone positions, while less quiet sleep, more awakening, and higher heart rates were recorded in supine.

* Corresponding author.
E-mail address: o_bart@bezeqint.net (O. Bart).
[1] The author was at the Department of Occupational Therapy of Tel Aviv University at the time of the study.

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Several studies have demonstrated that the falling asleep phase was shorter and the duration of sleep was longer in the prone position than in the supine position, thus helping the preterm infant to conserve vital energy for growth (Grenier et al., 2003; Myers et al., 1997; Ravindra, Bhat, Pressler, Gerrard, & Rafferty, 2006). A number of studies also examined the association between positions in preterm infants and behavioral measures. Researchers found that in the prone position, premature infants cried less and reduced their motor activity (Ariagno, van Liempt & Mirmiran, 2006; Chang, Anderson, & Lin, 2002; Myers et al., 1997). Further studies found that in the prone position infants had better self regulating skills because they were more flexed and could comfort themselves more easily (Grenier et al., 2003; Leipala, Bhat, Rafferty, Hannam, & Greenough, 2003).

Als (1982) proposed the Synactive Theory of Development for explaining the capabilities of the preterm to self-regulate himself/herself. Self regulation in preterm babies is manifested in one's ability to achieve, maintain or regain self organization in all systems. Als (1982, 1986) defined the infant's behaviors towards achieving self regulation as approach reactions (e.g. foot clasp, finger folding, hand to mouth, grasping, sucking). According to the Synactive theory of development when self-regulation is not achieved the infant is in a state of stress and may presents withdrawal behaviors (e.g. hiccups, coughs, finger display, leg extension and sitting on air; Als, 1982).

Most studies that investigated the influence of position assessed medical outcomes and sleep patterns. Our goal was to evaluate the influence of positions (prone or supine) on infant sleep states and on calming and stress behaviors. Such information can indicate how to help preterm infants to better regulate themselves and conserve more energy, thus having a better foundation for optimal development. It is also important to reduce high stress behaviors of the premature infants as it was found that repetitive stress has been associated with adverse effects on development (Grunau, Oberlander, Whitfield, Fitzgerald, & Lee, 2001). Finally, the NICU team will be able to apply this information in their daily care and instruct parents.

2. Method

2.1. Participants

Thirty-two preterm infants (12 males, 20 females) born at Meir Medical Center, Israel, between January and July, 2002, were recruited into the study. Post menstrual age at birth ranged from 25 to 35 weeks ($M = 30.37$, $SD = 2.57$), with a mean birth weight of 1250 g ($SD = 313.86$, range 663–1745). Average post menstrual age at testing ranged from 29 to 38 weeks ($M = 33.22$, $SD = 1.99$). Inclusion criteria included birth weight less than 1750 g, appropriate for post menstrual age, stable in room air, with no major congenital anomalies or major neurological sequella (IVH, PVL) and with no medication that could influence the infant's sleep–awake cycle. The full sample comprised of 22 singletons, and 10 multiples (twins and triplets).

2.2. Measures

Actigraph: The miniature Actigraph (AMA-32, Ambulatory Monitoring, and Ardsley, NY) is a wristwatch like device, approximately $4.5 \times 3.2 \times 1.1$ cm that is attached to the infant's ankle, by a small band and measures the infants' movements.

Unfortunately, there is no data regarding the reliability and validity of the actigraphic assessment in preterm infants. Sleep–wake states of premature infants may partially reflect external movements, such as feeding or medical handling. In spite of such problems actigraphy is considered an objective and nonintrusive method of measuring infant sleep (Goto et al., 1999). An overall minute-by-minute agreement rate of 95.7% was obtained during the first year of life (including newborns), between actigraphic, automatic sleep–wake scoring and parallel scoring obtained from the method of direct observation and respiration pad following the procedure described by Sadeh, Acebo, Seifer, Aytur, & Carskadon, 1995; Sadeh, Alster, Urbach, & Lavie, 1989; Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991. In this study, we have used the algorithm that has been validated with the newborns (Sadeh, Acebo, et al., 1995; Sadeh, Hauri, Kripke, & Lavie, 1995). In addition, to validate the use of Actigraph with preterm babies we computed Pearson correlation between the Actigraph measures and the observation measures. We aggregated the observations into two categories; one of sleep state and one of awake state. The same aggregation was done with the Actigraph measurements. Significant moderate correlations were found between the sleep state as measured by the two methods ($r = .57$, $p < .001$), and between the awake state ($r = .47$, $p < .01$).

The actigraphic measures are based on 48 h sleep–wake cycles and include: activity level and percentage of time the infant spent in each state (awake, light sleep and deep sleep).

2.3. Naturalistic Observation of Newborn Behavior (NONB)

The NONB is a formal observation of the behavior of the preterm infant based on the Newborn Individualized Developmental Care and Assessment Program (NIDCAP) intervention model (Als, 1995; Als et al., 2003). The observation includes the two major behavioral reactions of the preterm infant: approach (that portray calm, soothing, and self regulatory behaviors) and withdrawal, (that portray avoidance, protective, and stress behaviors; Sadeh, Hauri, et al., 1995).

In addition the NONB includes observation of the six sleep and awake states as defined by Brazelton (1984) (deep sleep, light sleep, drowsy, quiet awake, active awake, and agitated fussy). The observation total score is the summing up of the number of approach and withdrawal reactions, and of sleep–awake states.

2.4. Procedures

The Institutional Review Board of Meir Medical Center approved the study and a written informed consent was obtained from all parents. All preterm infants participating in the study were in incubators in the NICU at the Meir Medical Center throughout the duration of the study. At the time of the study, lights were on 24/7, and sound level was moderate. There were approximately 15 babies in the room with 5–6 nurses during each shift.

Each participant, 2–3 weeks after birth, was observed for 48 h, a wrapped Actigraph was secured by the nurses to the preterm infants' ankle. Data collection consisted of two successive 48-h sessions of activity monitoring. The Actigraphs were initialized and downloaded in the sleep clinic at the Tel Aviv University where all raw data was analyzed using the ASA program for IBM compatible PCs (Sadeh, Hauri, et al., 1995; Sadeh, Sharkey & Carskadon, 1994) by the same experienced technician who was blind to the infants position.

Follow-up forms were attached to the babies' bedside medical record to record the changes in position, feeding and other procedures. Positions (prone and supine) were altered after every feeding if the infant was fed every 3 h or after every other feeding if the infant was fed every 2 h. In total the infant was monitored 24 h in each position.

Two daily 30-min NONB observations (30 min before feeding and 30 min after feeding) were recorded for each baby during these 48 h by two trained occupational therapists for a total of four 30-min observations. Inter-rater reliability between the two therapists was high ($r = .92$). We administered a random start method of prone or supine sleep position. To reduce biases in data collection, sleep positions before feeding (supine or prone) were alternated between the 2 days of the observation. For example, if on the 1st day the preterm was positioned in supine before feeding, then on the second day, he or she was positioned prone before feeding. In addition, if the infant was observed first in the prone position, on the next day he or she was first observed in supine. Physiological measurements such as heart rate, respiratory rate and saturation were recorded to monitor the preterm infant's response and be sure that they remained stable throughout the observations. Sleep–awake states and approach-withdrawal reactions were recorded on the NONB form every 2 min during each of the 30-min observations for a total of 2 full hours (1 h each day, 1 h in each position). Approach reactions include: Hand on face, Smile, Mouthing, Suck Search, Grasping, Hand to mouth, Ooh face, Locking, and Coohing. Withdrawal reactions include: Grimace, Airplane, Arching, Sitting on air, Yawn, Sneeze, Averting, Frown, Hiccup, and Finger splay.

2.5. Data analysis

Data from the Actigraph and from the NONB were analyzed separately and independently for supine and prone position. From the Actigraph: (1) mean activity level of the entire duration of observation separately for supine and prone, (2) awake percent, (3) active sleep percent, and (4) quiet sleep percent. From the NONB: (1) number of approach reactions, (2) number of withdrawal reactions, and (3) number of times each of the six sleeping states were observed.

In order to assess the influence of prone and supine position on behavioral reactions (withdrawal and approach) and on sleep, two way analyses of variance, with repeated measures (ANOVA) on both factors were performed. In order to make sure that time of feeding before or after observation did not affect the results we included it in one of the analysis. The correlation between sleep and reactions was tested with Pearson correlations.

3. Results

3.1. Withdrawal and approach reactions during prone and supine positioning

In order to test for differences between withdrawal and approach reactions in supine vs. prone position, a two way analysis of variance, with repeated measures (MANOVA) on both factors was performed. Preterm infants had more reactions in the supine position as compared to the prone position ($F(1,31) = 20.07$, $p < .001$), and more approach reactions as compared to withdrawal reactions ($F(1,31) = 37.23$, $p < .001$). However, those results are superseded by the significant interaction effect between position and type of behavioral reactions ($F(1,31) = 53.24$, $p < .001$). Post hoc analysis revealed that in the prone position there were more approach reactions as compared to withdrawal reactions, while in the supine position there is no significant difference between withdrawal and approach reactions (see Fig. 1). While approach reactions were comparable between prone and supine positions, more withdrawal reactions were observed in the supine position ($p < .001$).

3.2. Position (prone and supine), feeding and sleep states (Actigraph measures)

To assess the effect of positioning and feeding on sleep states, a two way ANOVA, with two repeated measures: position (2) and feeding (2), was performed. Feeding time was included intentionally to control for the effect of feeding on the preterm infant's behavior. The position regime of supine and prone allowed testing each preterm infant before and after feeding, in each position to control for the positions' effect. However, feeding was not found to affect the sleep states, and the interaction of position and feeding was not significant either (see Table 1). Therefore feeding was not included in further analysis.

On the other hand, position significantly affected the sleep states. The Actigraph measurements show that in supine position infants spent more time in awake state with significant higher activity level and less time in quiet sleep (see Fig. 2).

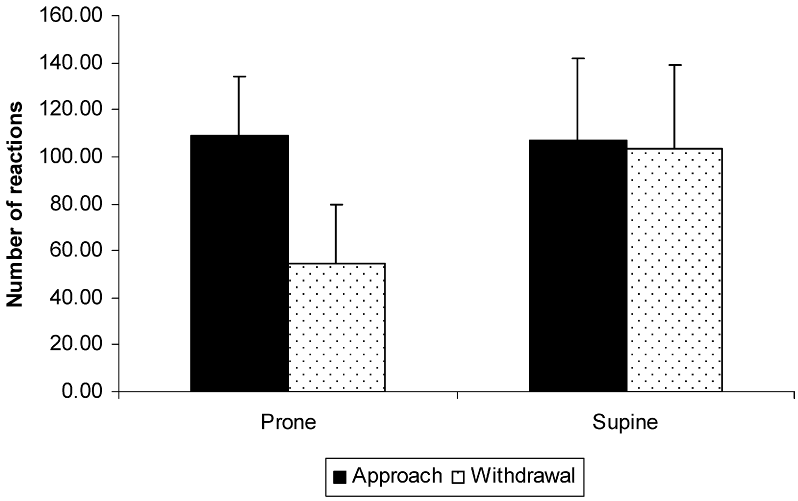

Fig. 1. Approach and withdrawal reactions during prone and supine position.

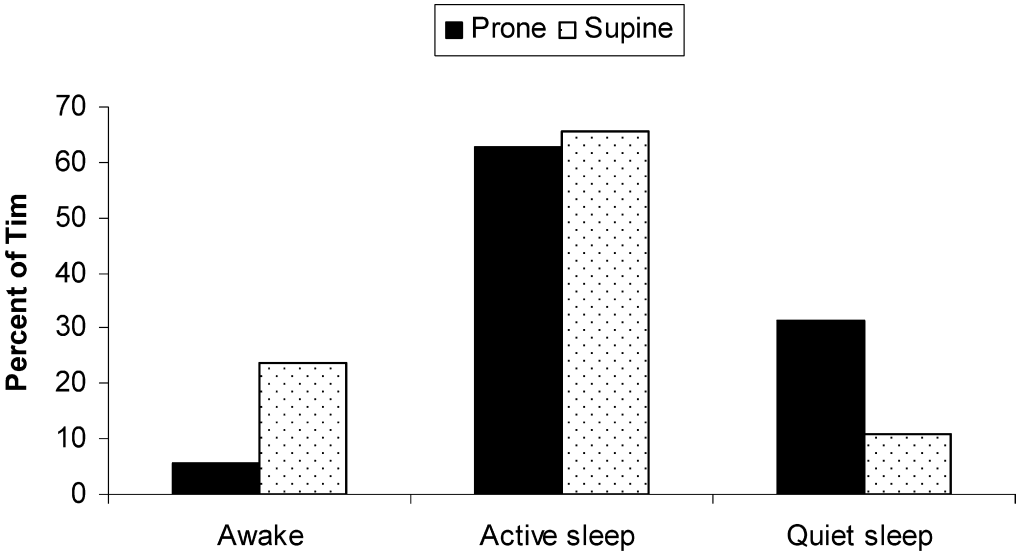

Fig. 2. Mean Actigraph measures during prone and supine position.

3.3. *Position (prone and supine) and Brazelton's sleep states (observational measure)*

To test for the effect of the positions on sleeping states, a two way ANOVA, with repeated measures: position (2) and sleeping states (6), was performed. A significant main effect for sleeping states was found ($F(5,155) = 40.57$, $p = .0001$), while there was no significant effect for position ($F(1,155)$ 0.63, $p = .43$). There was a significant interaction between position and sleeping states ($F(5,155) = 6.1$, $p = .0001$). Post hoc analysis revealed that deep sleep was observed more in the prone as compared to supine position while light sleep was observed more in supine than in prone (Fig. 3).

Table 1
The effect of prone and supine positions and feeding (before and after) on sleeping measures as measured by Actigraph ($N = 32$).

	Activity level		Awake %		Active sleep %		Quiet sleep %	
	F	*p*	*F*	*p*	*F*	*p*	*F*	*p*
Position	30.38***	.001	17.01***	.001	0.15	.70	9.13***	.001
Feeding	3.71	.06	0.90	.35	0.04	.84	2.00	.16
Position × feeding	0.10	.75	0.01	.90	0.02	.88	0.10	.75

*** $p \leq .001$.

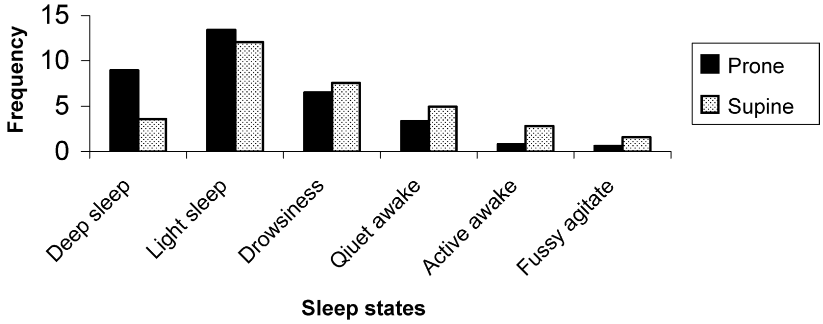

Fig. 3. Mean of sleep/awake scores during prone and supine position.

Table 2
Pearson correlations between sleep patterns and number of approach/withdrawal reactions in each position.

	Prone		Supine	
	Approach	Withdrawal	Approach	Withdrawal
Actigraph				
Sleep	0.19	−0.015	−0.20	−0.12
Awake	0.45**	0.32	0.31	0.23
Observation				
Deep sleep	−0.21	0.31	0.15	−0.37*
Light sleep	0.30	0.06	−0.25	−1.14
Drowsy	0.32	0.37*	0.21	0.32
Quiet awake	0.41**	0.18	0.11	0.17
Active awake	0.08	0.41**	0.35*	0.03
Fussy/agitate	0.4*	0.06	0.21	0.25

* $p \leq .05$.
** $p \leq .01$.

3.4. Position (prone and supine), sleep states, and withdrawal and approach reactions

The correlations between sleep states and withdrawal and approach reactions during prone and supine position were tested using Pearson correlations. Very few correlations were found between the sleep states measures and behavioral reactions (see Table 2). Most of the significant correlations were between the observation measures and withdrawal and approach reactions in the prone position. More specifically, higher quiet awake and fussy states were associated with more approach reactions in prone. In addition, higher active awake and drowsy states were associated with more withdrawal reactions in prone.

4. Discussion

The present study was conducted to establish knowledge about the influence of supine and prone positions on sleeping patterns and on withdrawal/approach reactions of the preterm infant. A significant interaction was found between infant position and behavior. In the prone position there were many more approach reactions than withdrawal reactions. This may be attributed to the effect of the tonic labyrinthine reflex, which is prevalent in the prone position, and can cause more flexor activity. This may block the infant's ability to perform some of the withdrawal reactions, such as sitting on air. This may helps the preterm to sleep better and to self-regulate. This finding supports previous studies indicating that when medically feasible, the prone position is preferred for preterm infants because it encourages self-regulatory behaviors (Ariagno, van Liempt & Mirmiran, 2006; Chang, Anderson, & Lin, 2002; Grenier et al., 2003; Leipala, Bhat, Rafferty, Hannam, & Greenough, 2003; Ravindra et al., 2006) and preterm infants cry less and move less in this position, thus conserving energy (Ravindra et al., 2006; Young, 1994).

In the supine position, compared to the prone position, there was a higher frequency of reactions in general, suggesting that this position allows the head and extremities more freedom of movement. In addition, in the supine position the preterm infant is more exposed to a vast amount of environmental stimuli such as visual input that require challenging adjustments. Different studies have shown that the supine position may cause more stress related reactions (Chang, Anderson, & Lin, 2002; Galland, Taylor, & Bolton, 2002), and disturbs sleep (Ariagno, van Liempt & Mirmiran, 2006; Goto et al., 1999). The current study found the same number of approach and withdrawal reactions in the supine position. Another study by Grenier et al. (2003) suggests that lying in the supine position is stressful for premature babies and therefore they try to actively sooth and regulate themselves by using more approach reactions. It is possible that the preterm infants in the current study, while lying in supine position, tried to regulate themselves by approach reactions, thus exhibiting both types of reactions. If this is the case, then it is important to note that even preterm infants can find ways to console themselves.

Our second goal was to assess the interaction between prone and supine positions and sleep–awake patterns. Indeed, a significant interaction was found. In the prone position more sleep patterns (deep sleep, light sleep, drowsy) were observed as opposed to more awake patterns (quiet awake, active awake and agitated fussy) in the supine position. These findings are in accordance with other studies that indicate that preterm infants fall asleep more quickly and sleep for longer periods of time in the prone position (e.g. Chang, Anderson, & Lin, 2002; Goto et al., 1999).

Only a few significant relationships were found between sleep states and approach or withdrawal reactions. Specifically, in the supine position, as was observed using the NONB, there was a positive correlation between active awake states and approach reactions. This may be due to the baby being awake in supine, receiving less surface support, and therefore more movement can be performed (Grenier et al., 2003). This high frequency of movement may reflect the infant's need to self regulate. While in deep sleep, less withdrawal reactions were exhibited as the infant is relaxed, calm, and finally benefits from complete rest. In the prone position, there were positive associations between the quiet awake and agitated fussy sleep states to approach reactions. On the one hand, when the infant is relaxed and in the quiet awake state, he or she is able to positively react to the environment. On the other hand, when the infant is in the agitated fussy state, he or she needs the approach reactions to console and self-regulate. In addition, a positive correlation was also found between drowsiness and active awake sleep states and withdrawal reactions in prone. In the present study, the differences between the two extreme sleep states (deep sleep and fussy agitated) were clear but sometimes it was difficult to differentiate between the 4 remaining sleep/awake states as the preterm infant states are less distinguishable (Watt & Strongman, 1995; Gertner et al., 2002).

4.1. Limitations

The use of Actigraph, which is considered a standardized and objective measure of sleep, revealed only moderate correlation between wakefulness states and approach reactions in the prone position. There is support in the literature to the use of Actigraph to measure sleep patterns in infants but not in preterms (Cole, Alessi, Chambers, Moorcroft, & Pollak, 2003; Gnidovec, Neubauer, & Zidar, 2002; Sadeh, Acebo, et al., 1995; Sadeh, Hauri, et al., 1995). Although the Actigraph was validated only on term babies, several studies used this method with preterm infant as well (Fay, 1995; Watt & Strongman, 1995). In addition, we validated the Actigraph against direct observations.

It is important to note that this study results may not be applicable to all preterm babies as in our study only 32 stable preterm infants were assessed at the average age of $M = 33.22$, $SD = 1.99$. The age range of infants was wide and during this period brain maturation occurs and changes in behavior may be observed. Further studies are important to evaluate the influence of position on higher risk preterm infants and at different post menstrual ages. We had more females than males in our study however there were no significant differences between males and females on all behavior and sleep measures. Our small sample size did not allow us to evaluate the findings by infant gender but further studies may also assess gender effect.

4.2. Clinical implications

The study results encourage placing the preterm infant in prone since this enables important achievements such as longer periods of quality sleep, conserving more energy for growth, and producing adaptive self-regulatory reactions. Placing the infant in supine is effective mainly in the active awake state as they exhibit many approach reactions while calm, but once the preterm infant reaches the stressed agitated fussy state the infant is unable to self-regulate in this position. It is suggested then, to place the preterm infant in prone in order to facilitate approach reactions while in the NICU since the infants there are under close supervision of staff and monitors which prevent the possible complications leading to Sudden Infant Death Syndrome (SIDS). Yet, this recommendation needs further thought regarding sleeping adjustments that may be difficult to alter after discharge.

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