

# Comparison of Motor Self-Regulatory and Stress Behaviors of Preterm Infants Across Body Positions

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## KEY WORDS

- nesting
- positioning

Occupational therapists working with infants in neonatal intensive care units (NICUs) make positioning recommendations to optimize self-regulation, with little published data supporting this practice. In this retrospective descriptive study, 15 hospitalized preterm infants ( $M_{\text{gestational age}} = 32$  weeks) were videotaped during non-caregiving periods in order to record the frequency of specific behaviors in relation to six infant positions (prone nested, prone un-nested, side-lying nested, side-lying un-nested, supine nested, and supine un-nested). Behaviors coded were those that suggest infant stress or motor efforts at self-regulation, as defined for the original study. Mixed effects regressions and post-hoc Tukey Honestly Significant Difference tests were used to analyze the data, after the calculation of a ratio of the number of behaviors in each position. Higher ratio values reflect a greater occurrence of behaviors.

The number of motor self-regulatory and stress behaviors were related to infant position, with the highest ratios of behaviors observed in side-lying un-nested and the lowest in prone nested. Behavior ratios did not differ between prone un-nested and prone nested, nor between supine un-nested and supine nested. More self-regulatory and stress behaviors were related to longer periods of fussing and crying. Longer periods of light sleep were related to fewer stress behaviors.

Infants performed the fewest stress behaviors in prone nested, prone un-nested, or side-lying nested. These positions may benefit infants in the NICU by reducing the need for motor-based self-regulatory behaviors and potentially conserving energy for growth.

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**P**ositioning recommendations to promote self-soothing behaviors and enhance self-regulation are included in the individualized developmentally supportive care model, which has evolved from the synactive theory of infant development and provides guidelines for developmentally appropriate caregiving in the neonatal intensive care unit (NICU) (Als, 1982, 1986). Clinical application of the individualized developmentally supportive care model is believed to help ameliorate the potentially negative effects of stress that preterm infants experience in NICUs (Als et al., 1986). These effects are considered detrimental to infant progress in the NICU when they impose demands on the infant that exceed the infant's coping abilities. Several studies have suggested improved overall developmental and medical outcomes among infants cared for using the individualized developmentally supportive care model (Als et al., 1986; Als et al., 1994; Buehler, Als, Duffy, McAnulty, & Liederman, 1995; Fleisher et al., 1995; Westrup, Kleberg, von Eichwald, Stjernqvist, & Lagercrantz, 2000).

One important goal of individualized developmentally supportive care is to support self-regulatory abilities (i.e., the active efforts on the part of the infant to regulate autonomic functions, motor control, and states of arousal, and availability for interactions with others, within the context of a dynamic environment) (Als, 1982). Based on infant observation, certain motor behaviors are thought to be

indicative of infant self-regulation (Als, 1982, 1986, 1992; Als, Lester, & Brazelton, 1979). The model proposes several strategies that can be implemented by caregivers to facilitate regulation in infants based on individual behavioral repertoires. Some strategies have been documented by research, whereas others are based on anecdotal evidence. One strategy frequently recommended by clinicians is positioning to promote flexion, hand-to-mouth, and grasping and tucking motions, to enhance self-regulation by encouraging stability of the motor system (Lawhon & Melzar, 1988; Lotas & Walden, 1996; Yecco, 1993). Examination of the relation between positioning and enhanced self-regulation may substantiate the use of positioning strategies by occupational therapists and other caregivers to facilitate self-regulation through support to the motor system.

Often based on anecdotal evidence, occupational therapists implement positioning strategies in efforts to reduce stress in the premature infant (Case, 1985). Generally, containment and positions of flexion are used to facilitate self-calming when signs of stress are demonstrated (Als & Gilkerson, 1997), and to promote participation in infant-related occupations, including feeding and social interactions. Hospitalized preterm infants are exposed to a variety of positions, and some clinicians speculate that prone positioning is desirable for preterm infants because it is thought to promote self-regulatory behaviors such as bringing the hand to the mouth (Case, 1985; Lynch, 1997; Turrill, 1992; Warren, 1992; Young, 1994). The supine position, however, is considered to be less desirable because it does not promote flexion (Turrill, 1992), and is thought to lead to instability of the infant's attentional, state, motor and autonomic systems (Als, 1982).

The studies that have examined positioning effects on preterm infants have focused on the basic capacities of regulating state of arousal and physiologic control. Results indicate that the prone position may be more desirable for infants, as infants have been found to sleep more, cry less, move less, and achieve a quiet sleep state more quickly and for longer periods after feedings when placed in the prone position (Brackbill, Douthitt, & West, 1973; Masterson, Zucker, & Schulze, 1987; Myers et al., 1998). Other findings indicate improved oxygenation when preterm infants are placed in the prone position compared to supine (Baird, Paton, & Fisher, 1992; Martin, Herrell, Rubin, & Fanaroff, 1979<sup>1</sup>; Schwartz, 1993). Bjornson and colleagues (1992) found improved oxygen saturation when infants were in prone, compared to the supine and side-lying positions.

Positioning, however, did not significantly affect heart rate within 2 hours of birth (Schwartz, 1993), respiratory rate, or ventilation (Baird et al., 1992; Martin et al., 1979; Schwartz, 1993).

Occupational therapists in NICUs make positioning recommendations to facilitate optimal functioning of hospitalized preterm infants. Although there is evidence to support positioning considerations for control of states of arousal, improved cardio-respiratory function, and energy conservation, the implementation of positioning strategies to facilitate self-regulation within the motor subsystem has been minimally studied. The purpose of this study was to examine whether a relation exists between preterm infant position and the frequency of motor-based self-regulatory and stress behaviors using an existing data set.

## Method

This study was a retrospective descriptive examination of an existing data set of videotapes of hospitalized preterm infants. Twenty-five videotapes were analyzed to record frequency of self-regulatory and stress behaviors during non-caregiving periods. Relationship to six infant positions (prone nested, prone un-nested, side-lying nested, side-lying un-nested, supine nested, and supine un-nested) was investigated.

## Participants

The participants of this study were 7 male and 8 female medically stable singleton (i.e., not of a multiple birth) preterm infants in the special care and continuing care nurseries of an urban women's hospital, born to families of average socioeconomic status. Infants who were considered nonviable by the neonatologist, had a congenital anomaly, active sepsis at the time of assessment, had parents under investigation by the Department of Children, Youth and Families, or whose mother had a psychiatric diagnosis were excluded from the original study. Following institutional review board approval, parents of all other premature infants born between 23 and 30 weeks' gestation during the time of enrollment were invited to participate. Demographic information obtained for the 15 preterm infants whose parents gave consent included gender, birth weight, gestational age at birth, prenatal and perinatal history, and medical diagnosis data (Table 1). Ten mothers had received prenatal care during their pregnancy; 5 infants had been delivered by cesarean section, 3 had intraventricular hemorrhage, 10 had bronchopulmonary dysplasia, 12 had respiratory distress syndrome, 6 had retinopathy of prematurity, and 3 had necrotizing enterocolitis.

<sup>1</sup>This study was completed prior to the introduction of surfactant for use with preterm infants.

**Table 1. Participant Mean Birthweight, Gestational Age, and Apgar Scores.**

	<i>n</i>	<i>M</i>	<i>SD</i>	Range
Birthweight (grams)	15	876.5	156.4	530–1285
GA at Birth (weeks)	15	26.1	1.2	23–29
Apgar 1	14	5.14	2.31	0–9
Apgar 5	14	6.5	1.5	3–9

Note. GA = Gestational age in weeks.

Apgar 1 = Apgar score at 1 minute of life (scale is from zero to ten, representing the infant's physical status, based on heart rate, respiratory effort, muscle tone, response to stimulation, and skin color; a higher score is optimal)

Apgar 5 = Apgar score at 5 minutes of life (Apgar, 1953)

## Procedure

The existing data set contained two videotaped observations of 13 infants, and a single videotape of each of two additional infants. The second videotape of the 13 infants occurred within 1 to 13 days of the first videotape, with most videotapings occurring either 3 or 7 days after the first. Participants had a mean gestational age of 31.6 weeks ( $SD = 1.2$ ) at the time of the first videotaping, and a mean gestational age of 32.1 weeks ( $SD = 0.9$ ) at the time of the second videotaping.

Each videotaped observation included three consecutive periods: baseline, caregiving, and recovery. The baseline period consisted of approximately 10 minutes of recording immediately preceding a scheduled caregiving period (i.e., feeding, diaper change), and the recovery period included approximately 10 minutes of videotaping immediately following the termination of the caregiving period. Duration

of the caregiving period varied. Videotaping procedure dictated that the video camera remain in the same position for the duration of an observation, unless its position interfered with caregiving, or the view of the participant was poor. For the purposes of this study, only the baseline and recovery periods were examined.

The behaviors coded for this study were categorized as self-regulatory or stress in nature based on definitions used in other studies (Als, 1982; Barnard, 1978; Bigsby, 1994; Bigsby, Coster, Lester, & Peucker, 1996; see Table 2). The conditions coded included time period (before, during or after caregiving), infant position (supine, side-lying, or prone), the presence of nesting (rolled blankets, boundaries created by blankets and a heat shield, any other detectable boundary), and infant state of arousal (Brazelton, 1984). The time at which each behavior or a change in condition was observed was recorded using the Action Analysis, Coding, and Training (AACT) computer software (Intelligent Hearing Systems, 10689 North Kendall Drive, Miami, Florida, 33176). The occurrence of all variables was recorded, except foot bracing, which was recorded by noting its duration from onset to termination in seconds. Only those behaviors for which inter-rater reliability of at least 80% agreement was established were coded and are reported.

Inter-rater reliability was defined as the percentage agreement between the first and second authors on three full videotapes from three different participants. Behaviors coded within a 2 second time frame by both coders were considered in agreement. An overall percent agreement of 91% for reliability was achieved.

**Table 2. Operational Definitions for Coding Behaviors.**

	Operational Definition (Als, 1982; Barnard, 1978; Bigsby, 1994, 1998; Bigsby et al., 1996)
Self-regulatory	
Munch	Lips and jaw open and close completely and repeatedly
Smile	Lips open and retract or corners of the mouth pull upward
Tongue protrude	Tongue protrudes beyond the lips; not during a munch
Eye raise	Brows move upward, shortening the brow
Hand-to-face	Hand touches anywhere on the face
Self-clasp	Infant grasps body, clothing or apparatus
Hand-to-mouth	Hand is brought to the mouth, with or without insertion
Foot brace	Feet are clasped together, one foot is clasped against the other leg, or pressed for at least 2 seconds against a nearby surface
Stress	
Yawn	Mouth opens in an exaggerated fashion and infant takes a prolonged inward breath
Arch	Shoulders retract, trunk is extended, and the head is thrust back
Sit-on-air	Legs are raised symmetrically off the surface with knees extended and hips flexed
Squirm	Arms, legs, and trunk are moved in a restless random fashion
Startle	Quick, total body movement in response to a stimulus
Salute	Arm(s) and fingers are held in extension for at least 2 seconds
Arm wave	Arm(s) move repeatedly in alternate extension and flexion at the shoulder or elbow or both
Finger splay	Hand opens strongly, the fingers are extended and separated from each other
Leg extension	Straightens legs and holds position in space (no contact with surface) for at least 2 seconds
Kicking	Unilateral or bilateral symmetrical flexion and extension of the leg(s)

## Data Reduction and Analysis

The data collected during the first 10 minutes of the baseline period and the entire recovery period were analyzed. Of 28 available videotapes, 3 were discarded because of problems such as a frequently moving camera or inadequate length of videotape. The 25 remaining videotapes represented data from 15 participants: Five contributed one video each and 10 contributed two videos each to the data set.

Initial data inspection revealed that position changes did not occur within any individual baseline or recovery period. Of the 50 observation periods obtained (25 videotapes X two periods), there were 17 observations in the prone un-nested position, 15 in prone nested, and 6 in supine un-nested. Side-lying nested, side-lying un-nested, and supine nested were observed 4 times each. Preliminary analysis using Fisher's Exact test revealed no statistically significant differences in the frequency of occurrence of each position between the two periods, with  $p$  values ranging from 0.157 to 1.000; therefore, position data for the two periods were combined for further analyses. To accommodate for the unequal number of observations in each position, ratio scores were calculated. The ratio score was derived as follows:

$$\text{Ratio of } x \text{ behavior} = \frac{\text{Occurrence of } x \text{ behavior in } y \text{ position}}{\text{Number of infants videotaped in } y \text{ position}}$$

A higher ratio of a behavior indicates a higher frequency of its occurrence, and conversely, a lower ratio of a behavior indicates fewer observations of that behavior. Standard deviations of the ratio scores were large; therefore, the data were transformed into  $z$  scores for further analyses.

To determine the relation between position and motor based self-regulatory and stress behaviors, a mixed effects regression analysis was conducted on the  $z$  scores of the behaviors and positions (Hedeker & Gibbons, 1996). This statistical analysis treated participants as random effects in order to account for the correlation between multiple observations from the same participant, and yielded an  $F$  value of the overall strength of the relation between position and behavior. The mixed effects regression analysis also provided pair-wise comparisons between the behavior ratios obtained for each position and a reference position (prone un-nested). Prone un-nested was established as the reference group for the pair-wise comparisons because it was the position most frequently observed. Position, the duration of each state of arousal, and gestational age at time of videotaping were entered into the regression together in order to examine position as a predictor while accounting for other potential influences.

## Results

### *Frequency of Self-Regulatory and Stress Behaviors in Baseline Versus Recovery*

During baseline, a total of 189 stress behaviors ( $M = 7.56$ ,  $SD = 6.06$ )<sup>2</sup>, and 194 self-regulatory behaviors ( $M = 7.76$ ,  $SD = 10.04$ ) were observed. Foot bracing was observed for a total of 1,709 seconds, with an average duration of 68.36 seconds ( $SD = 160.00$ ). During recovery, a total of 185 stress behaviors ( $M = 7.40$ ,  $SD = 10.57$ ), and 204 self-regulatory behaviors ( $M = 8.16$ ,  $SD = 11.76$ ) were observed; foot bracing was observed for a total of 1,088 seconds ( $M = 43.52$ ,  $SD = 88.38$ ). The  $t$ -test analyses on the raw scores revealed no significant differences between baseline and recovery periods for all variables ( $p > 0.05$ ), except startle. Because 17 of the 18 behavioral variables did not show statistically significant differences between the baseline and recovery periods, behavior data from the two periods were combined for further analyses.

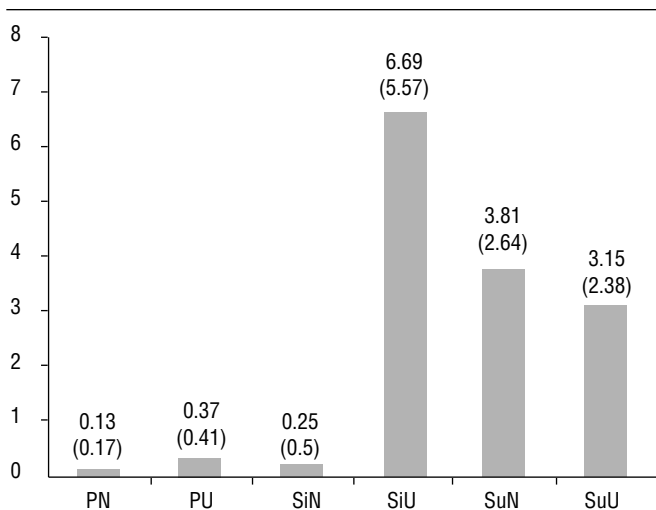
### Self-Regulatory Behaviors

The summary variable "self-regulatory behaviors" was calculated by combining the individual motor based self-regulatory behavior ratios across infants for each position. The position in which the highest self-regulatory behavior ratio (mean) score occurred was side-lying un-nested; the lowest score occurred when participants were in the prone nested position (Figure 1). There was a statistically significant relation between position and self-regulatory behaviors,  $F(5, 44) = 12.10$ ,  $p < 0.001$ . The mixed effects pair-wise comparison analyses revealed that the ratio of self-regulatory behaviors was higher when participants were in the side-lying un-nested, supine un-nested, and supine nested positions than when in the prone un-nested position, indicating fewer self-regulatory behaviors were observed when infants were prone un-nested (Table 3). When the gestational age at the time of videotaping and average duration of each state of arousal were added to the model, the relation between position and self-regulatory behavior ratios was retained ( $p < 0.001$ ), suggesting that neither gestational age nor the length of time spent in individual states of arousal was related to the frequency of self-regulatory behaviors seen.

#### *Foot Bracing*

Foot bracing was analyzed separately due to the method by which it was recorded (i.e., as a durational versus frequency variable). A statistically significant relation between position

<sup>2</sup> Numbers reflect behavior counts prior to transformation into  $z$  scores.



**Figure 1. Mean Self-Regulatory Behavior Ratio Scores of 15 Hospitalized Preterm Infants, by Position.**

*Note.* Values reflect ratios prior to z transformation. A higher ratio score indicates a greater frequency of behavior. Values in parentheses represent standard deviations. PN = Prone Nested, PU = Prone Un-nested, SiN = Side-lying Nested, SiU = Side-lying Un-nested, SuN = Supine Nested, SuU = Supine Un-nested.

and the ratio of the duration of foot bracing was identified,  $F(5, 44) = 4.53, p = 0.002$ . The mixed effects pair-wise comparison analysis revealed a significantly higher ratio of foot brace duration in the side-lying un-nested position ( $M = 48.25, SD = 64.26$ ) than in the prone un-nested position ( $M = 5.96, SD = 10.78$ ). When the gestational age at the time of videotaping and durations of states of arousal were added to the model, the relation was maintained ( $p < 0.02$ ). This suggests that neither infant gestational age at the time of videotaping nor the amount of time spent in a particular state of arousal decreased the strength of the relation found between position and duration of foot bracing observed.

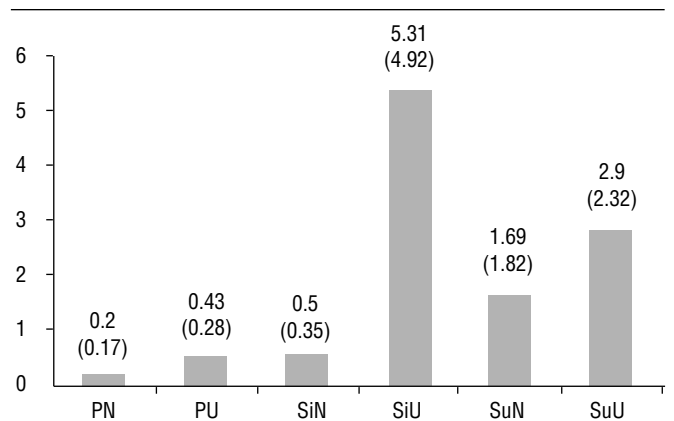
### Stress Behaviors

The summary variable “stress behaviors” was calculated by combining the individual motor based stress behavior ratios for each position. Overall position and the ratio of stress behaviors were significantly related,  $F(5, 44) = 8.88, p < 0.001$ . The position in which the highest stress behavior ratio (mean) score was obtained was side-lying un-nested;

**Table 3. Mixed Effects Pair-Wise Comparison Analysis of Self-Regulatory and Stress Behavior Ratios (z scores) of 15 Hospitalized Preterm Infants, by Position.**

Position	Self-regulatory				Stress			
	<i>M</i>	<i>SD</i>	<i>t</i> ( <i>df</i> =44)	<i>p</i> <=	<i>M</i>	<i>SD</i>	<i>t</i> ( <i>df</i> =44)	<i>p</i> <=
Prone nested	-0.477	0.064	-0.36	0.717	-0.439	0.080	-0.36	0.719
Prone un-nested	-0.389	0.153	.	.	-0.344	0.130	.	.
Side-lying nested	-0.433	0.188	-0.12	0.907	-0.308	0.165	0.09	0.9325
Side-lying un-nested	1.985	2.094	6.24	0.001	1.943	2.300	5.53	0.001
Supine nested	0.905	0.992	3.40	0.001	0.248	0.851	1.43	0.160
Supine un-nested	0.657	0.894	3.22	0.002	0.816	1.086	3.28	0.002

*Note.* The reference group is prone un-nested.



**Figure 2. Stress Behavior Ratio Scores of 15 Hospitalized Preterm Infants, by Position.**

*Note.* Values reflect ratios prior to z transformation. A higher ratio score indicates a greater frequency of behaviors. Values in parentheses represent standard deviations. PN = Prone Nested, PU = Prone Un-nested, SiN = Side-lying Nested, SiU = Side-lying Un-nested, SuN = Supine Nested, SuU = Supine Un-nested.

the lowest score was obtained in prone nested (Figure 2). The ratio of stress behaviors was significantly higher in the side-lying un-nested and the supine un-nested positions than in the prone un-nested position, indicating that more stress behaviors were seen when infants were positioned un-nested in side-lying or supine (Table 3). When gestational age at time of videotaping and duration of each state of arousal were added to the model, the relation between the ratio of stress behaviors and position was maintained ( $p < 0.001$ ).

### Effect of State Duration and Gestational Age at Time of Videotaping

The duration of state 2 (light sleep) was significantly related to stress behaviors ( $p < 0.037$ ). There were fewer stress behaviors recorded when infants were in light sleep. The durations of state 5 and state 6 (active alert, and crying, respectively) were significantly related to self-regulatory behaviors and stress behaviors ( $p < 0.008$ ), such that more behaviors were recorded when infants were fussing or crying. The durations of neither state 1 (deep sleep), state 3 (drowsy), nor state 4 (quiet alert) were significantly related to the self-regulatory behaviors or stress behaviors observed.

Gestational age at time of videotaping was not significantly related to the observation of behaviors by position ( $p > 0.05$ ).

### *Post-Hoc Analysis*

A post-hoc analysis of variance (ANOVA) was conducted to compare the  $z$  scores of self-regulatory and stress behavior ratios in each position. A Tukey's Honestly Significant Difference test was performed to further examine the pairwise comparisons among the behaviors, by position.

### *Self-Regulatory Behaviors*

Significantly higher self-regulatory behavior ratios were obtained when infants were positioned in side-lying un-nested than when in side-lying nested, supine un-nested, prone nested, or prone un-nested,  $p < 0.05$ . This indicates that infants in side-lying un-nested not only tended to demonstrate significantly more self-regulatory behaviors than those in prone un-nested (the reference group chosen for initial data analysis), but also more than those who were side-lying nested, supine un-nested, or prone nested. Participants in the supine nested and supine un-nested positions demonstrated significantly higher self-regulatory behavior ratios than infants who were prone un-nested or prone nested ( $p < 0.05$ ). No significant difference was found between the self-regulatory behavior ratios when infants were prone nested versus prone un-nested, nor between supine nested and supine un-nested ( $p > 0.05$ ).

### *Stress Behaviors*

Tukey's multiple comparison procedure showed a significant difference in the ratio of stress behaviors between the side-lying nested and un-nested positions, ( $p < 0.05$ ), such that more stress behaviors were observed when infants were in the side-lying un-nested position (means reported in Figure 2). When participants were side-lying un-nested, the stress behavior ratio score was also significantly higher in comparison to when infants were supine nested, prone un-nested, or prone nested ( $p < 0.05$ ). Significantly higher stress behavior ratio scores were obtained (i.e., more stress behaviors were observed) when participants were in supine un-nested than when prone un-nested or prone nested ( $p < 0.05$ ). A significant difference was not found between prone nested and prone un-nested, nor between supine nested and supine un-nested ( $p > 0.05$ ).

## **Discussion**

This study is the first to relate the occurrence of motor-based self-regulatory and stress behaviors with preterm infant body position. Our results are consistent with the lit-

erature that suggests that prone positioning is optimal for sleep and cardio-respiratory functions (Baird, Paton, & Fisher, 1992; Bjornson et al., 1992; Brackbill, Douthitt, & West, 1973; Martin et al., 1979; Masterson, Zucker, & Schulze, 1987; Myers et al., 1998; Schwartz, 1993). The occurrence of motor-based self-regulatory and stress behaviors was related to preterm infant position during non-caregiving periods. The position in which the highest self-regulatory and stress behavior ratios were obtained was side-lying un-nested. The lowest self-regulatory and stress behavior ratios were obtained in the prone nested position. Self-regulatory behavior ratios were higher in the supine nested and un-nested positions than in the prone nested and un-nested positions. Stress behavior ratios were higher in the supine un-nested position than in either prone position. Self-regulatory and stress behavior ratios did not differ significantly between the prone un-nested and the prone nested positions, nor between supine un-nested and supine nested. When duration of each state of arousal and gestational age at time of videotaping were accounted for in the analyses, the relations between position and self-regulatory and stress behavior ratios were maintained.

Several interpretations can be considered to explain the findings of this study. It is possible that in certain positions, the infant is less distressed and self-organization is maintained without necessitating active efforts from the infant. It is also possible that in certain positions, the infant is susceptible to experiencing stress, but is unable to perform self-regulatory motor behaviors (i.e., due to muscle weakness and inability to overcome the effects of gravity). When the infant demonstrates self-regulatory motor behaviors in a particular position, these behaviors may represent an attempt on the part of the infant to cope with mounting stress. Other positions may be inherently more challenging, in which case the stress may gradually deplete the infants' coping resources. In this latter scenario, the infant will predominately display stress behaviors with intermittent self-regulatory behaviors. Although these interpretations all require further scientific examination, our findings provide some support for each.

More motor based self-regulatory and stress behaviors (i.e., higher ratios) occurred when infants were placed in supine than in prone. These data support anecdotal reports that the supine position is stressful (Fay, 1988) and that the observed behaviors in supine may have been attempts to maintain organization in the presence of mounting stress. If supine positioning disrupts sleep, as the findings of Goto et al. (1999) suggest, active efforts to maintain or regain self-organization may be necessary, resulting in a higher ratio of behaviors when supine as observed in this study.

In contrast to supine positioning, prone has been associated with better autonomic functioning (Baird et al.,

1992; Bjornson et al., 1992; Martin et al., 1979; Schwartz, 1993). Improved autonomic control may support more mature motor and self-regulation functions, as proposed by the synactive theory of development (Als, 1982). If prone positioning alone acts as a self-regulation mechanism, infants in prone will experience less stress, and will display fewer stress behaviors. In addition, they may have less need to use motor-based self-regulatory behaviors to soothe themselves, as the infants in our study demonstrated.

It appears that the side-lying un-nested position was the least favorable position for preterm infants with respect to their ability to self-organize by performing motor behaviors. The minimal contact between the body and the supporting surface in side-lying may contribute to postural instability and stress, requiring the use of motor-based self-regulation behaviors to preserve organization, or to display stress behaviors when unable to self-regulate. Further, the side-lying un-nested position offers the least amount of postural support, and therefore may place more physical demands on the preterm infant to maintain a stable position, comfort, and self-organization. In this position, the highest ratio of startles was observed. Conversely, the prone position has been empirically associated with decreased startle responses (Fay, 1988; Vohr, Cashore, & Bigsby, 1999), perhaps because it affords greater contact with the supporting surface and, as a result, greater postural stability.

The differences between positioning with and without nesting were found to be statistically significant only for the side-lying position, with significantly lower behavior ratios occurring when nested compared to when un-nested. Provision of boundaries has been associated with more efficient self-regulation, more physiologic control, better motor organization, and improved neuromuscular development (Neu & Browne, 1997; Short, Brooks-Brunn, Reeves, Yeager, & Thorpe, 1996). Perhaps the boundaries and support provided by nesting in the side-lying position fosters self-regulation through increased postural stability and midline orientation, more stable autonomic functioning, and decreased extraneous movement.

In this study, however, the provision of nesting boundaries did not significantly affect the motor based self-regulatory and stress behavior ratios in either the prone or the supine positions. It is possible that inherent characteristics of the prone and supine positions make them either more or less organizing for preterm infants, regardless of physical boundaries. In prone, even without nesting, the infant can position the extremities in flexion with greater ease. Flexor positioning is considered an important element for self-regulation and autonomic functioning (Als, 1982; Fay, 1988). It is possible that the self-regulatory and stress behavior ratios did not differ when nested or un-nested in prone

because of improved autonomic functioning in this position. The similarity in the behavior ratios in prone nested and prone un-nested may have occurred because this position may be inherently soothing.

The pull of gravity on the infants' limbs in the supine position could also interfere with adoption of flexor postures. Although nesting in supine would presumably provide the flexor support that this position otherwise lacks, supine is also associated with more frequent sleep disturbances (Goto et al., 1999). Perhaps the combination of gravitational challenges and disrupted regulation of states of arousal in the supine position overrides any benefit of nesting on the preterm infant's ability to self-regulate. The role of nesting on the self-regulatory abilities of preterm infants (as measured by observable behaviors) requires further study.

The results of this study should be investigated further through the implementation of methods that allow for infants to be randomly assigned to a position, or positioning sequence, with a larger sample, using a software system that has a similar frame-by-frame precision feature as that used for this study. Findings of this study support the consensus in the literature that the prone position is most favorable for improved cardio-respiratory functioning and state of arousal control for hospitalized preterm infants, providing it does not interfere with medical and nursing care. The small sample of stable infants in this study demonstrated the lowest motor based self-regulatory and stress behavior ratios in the prone nested position. Prone un-nested and side-lying nested had the second lowest self-regulatory and stress behavior ratios. The side-lying nested position has not been as extensively studied as other positions, and further study is needed before side-lying with nesting can be recommended as an alternative to prone positioning for sick infants in the NICU.

Until such studies are completed, positioning should be evaluated on an individual basis in order to accommodate the medical and behavioral organizational needs of sick preterm infants. If lower motor based self-regulatory and stress behavior ratios (i.e., observation of fewer motor-based self-regulatory and stress behaviors) are indicative of better overall self-regulatory abilities, our findings suggest that stable preterm infants placed in the prone nested, prone un-nested, or side-lying nested positions may be less stressed, and better able to self-regulate than when placed in other positions. This study contributes to the occupational therapy knowledge base of the affordances of different positioning options. Our findings suggest that occupational therapists may facilitate improved ability to self-regulate to benefit infants in the NICU by promoting calm sleep states and conserving energy for growth through positioning recommendations. ▲

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This study was part of a larger descriptive pilot study examining the relation between preterm infant behavior and physiologic reactivity. This article is based on a thesis written by the first author in partial fulfillment of the requirements for the Advanced of Master of Science Degree in Occupational Therapy from Sargent College of Health and Rehabilitation Sciences, Boston University. Results of this study were presented at The Physical and Developmental Environment of the High Risk Infant, 2001, and the Biennial Meeting of the Society of Research in Child Development, 2001.

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