The Effects of a Neonatal Positioner on Scapular Rotation

Karen Monfort, Jane Case-Smith

Key Words: infant, high risk • infant, low birth weight • posture

Objective. This clinical study investigated the effects of an individually fabricated prone positioner on heart rate, respiratory rate, and scapular position of premature infants in the neonatal intensive care unit. The prone positioner consisted of dense foam with cutouts to position the shoulders forward and toward midline.

Method. Six measurements of scapular rotation, respiratory rate, heart rate, and behavioral state were made with 20 infants on and off the prone positioner. The repeated measures allowed each infant to act as his or her own control.

Results. Heart and respiratory rates were not significantly different between the two methods of prone positioning. Upward scapular rotation was significantly greater with the infant on the prone positioner. Behavioral state did not influence the results.

Conclusion. These results suggest that a prone positioner can be helpful in the prevention of scapular—humeral tightness and shoulder retraction commonly observed in premature infants.

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effective in reducing stress behaviors.

A number of studies have examined the effect of positioning on physiological functions, such as respiratory function, lung compliance and oxygenation (Carlo, Beoglos, Stavr, & Martin, 1989; Fox & Molesky, 1990; Heimler, Langlois, Hodel, Nelin, & Sasidharan, 1992), and heart rate (Mendoza, Roberts, & Cook, 1991). In their review of neonatal positioning, Long and Soderstrom (1995) cited nine studies that demonstrated beneficial effects of the prone position on pulmonary function, respiratory rate, heart rate, energy expenditure, and sleep behavior. Fox and Molesky (1990) proposed that the prone position improved the relationship between ventilation and perfusion and found that positioning in prone compared with supine promoted significantly higher partial oxygen pressure in the intubated neonate. These results support the belief that prone positioning has a physiological impact that improves respiratory function in the neonate. Baird et al. (1991) found similar results, concluding that transcutaneous oxygenation measures were significantly higher in the prone position and that these increases were stable for 2 hours.

Researchers have also examined the effects of devices used to support the infant's position, including waterbeds, waterpillows, rocking beds, and air mattresses (Korner & Schneider, 1983; Kramer & Pierpont, 1976; Saigal, Watts, & Campbell, 1986). Most of these devices have mobile surfaces that provide vestibular and proprioceptive stimulation. Specifically, use of waterbeds has been shown to decrease episodes of apnea (Korner, Kraemer, Haffner, & Cosper, 1975), and use of waterbeds and waterpillows has prevented head flattening (Hemtingway & Oliver, 1991; Schwirian, Eesley, & Cuellar, 1986). Research of static positioning devices is not evident in the literature. Empirical evidence of the benefits of static positioning devices is needed to determine their appropriate use with neonates.

Preterm Neuromotor Development

Although not well researched, a primary clinical goal of preterm infant positioning is to improve the neonate's neuromotor status. When compared with the full-term infant, the preterm infant demonstrates decreased tone that is asymmetrically distributed between upper and lower extremities (Hunter, 1996). Passive muscle tone in the preterm infant develops in caudocephalic progression in which flexor tone in the upper extremities emerges after lower-extremity flexion. Low muscle tone and minimal movement characterize the upper extremity through 32 weeks gestational age (Dargassies, 1977; Tison & Grenier, 1986).

The question of whether low muscle tone in the preterm infant is associated with later motor development has been considered in a number of studies. Georgieff and Bernbaum (1986), who followed the neuromotor development of preterm infants up to 18 months of age, found increased incidence of scapular retraction and abnormal muscle tone in the shoulder girdle during the first year, but the retraction usually resolved by 18 months of age. These authors hypothesized that predominant extensor postural tone and positioning practices were causative factors of the infants' scapular retraction. Orthopedic deformities that have been associated with positioning include rib cage flattening, extremely rotated or abducted extremities, and head molding or flattening (Semmler, 1989). The risk for these deformities seems to be related primarily to allowing the neonate to remain in any one position for an extended period (Hunter, 1996). The practice of positioning preterm infants to promote scapular rotation and associated movement of the arms toward midline may help them achieve the prerequisite skills for later motor development (e.g., hands to midline, bilateral manipulation). Hunter (1996) suggested that positioning in prone can promote increased flexor tone, greater symmetry, and increased opportunity to bring hands to mouth; however, the specific effects of prone position on postural tone and movement have not been researched.

Purpose

The purpose of this study was to determine the effects of two methods of prone positioning—with and without a positioning device—on preterm infants' heart rate, respiratory rate, and scapular rotation. The influence of the infants' behavioral state on the dependent measures was also analyzed.

Method

This study used a time series counterbalanced design to examine the differences in scapular rotation in preterm infants when positioned on and off individually fabricated prone positioners. Each infant in the study acted as his or her own control to reduce the effects of differing gestational ages, weights, and chronological ages.

Sample

The subjects included premature infants from one NICU who met the following criteria: (a) estimated gestational age under 36 weeks and (b) available for data collection for a period of 2 weeks. Subjects were excluded from the study on the basis of the following criteria: (a) documented chromosomal abnormality; (b) Grade 4 intraventricular hemorrhage or other severe neurologic insult; (c) upper-extremity fracture; (d) brachial plexus injury; and (e) documented scapular abnormality. Over a 4-month period, the first author invited the parents of every neonate that met the criteria to participate in the study. From the in-
fants with informed consent ($n = 32$), all six measures of the study were completed on 20. Fourteen subjects were girls. Fifteen subjects were Caucasian, one was black, one was Hispanic, and three were biracial. Distributions and means for estimated gestational age and birth weight are presented in Table 1. Diagnoses included respiratory distress syndrome, multiple gestation, bronchopulmonary dysplasia, intrauterine growth retardation, congenital anomalies of cleft lip and palate and ear malformation, and necrotizing enterocolitis.

**Instrument**

Four variables—heart rate, respiratory rate, scapular rotation, behavioral state—were measured for each subject during use of the prone positioner. Heart rate and respiratory rate were recorded with the visual information from the Hewlett Packard Component Monitoring System, M1008B.\(^1\) Respiratory rate display accuracy was ±1 respiration per minute (rpm) at 60 rpm, and heart rate display accuracy was ±10%. Behavioral state was rated with the six grades defined by Brazelton (1984): (a) deep sleep, (b) light sleep, (c) drowsy or semidozing, (d) quiet alert, (e) active alert, and (f) crying.

Scapular position was measured with four different centimeter measurements. The superior and inferior medial angles of the **scapula** were palpated and marked by a dot of washable ink drawn on a small piece of tape that was adhered to the subject's back. The first two values measured the distance across the back between the left scapula superior angle and the spine, then the right scapula superior angle and the spine. The second two values measured the distance across the back between the left and right inferior medial angles of the scapula and the spine. When the distance between the inferior angles increased and the distance between superior angles decreased, the scapula was in a position of upward rotation. Scapular upward rotation supports a position of shoulder flexion and horizontal adduction, bringing the subject's hands toward his or her face.

Before implementing the centimeter measurement of scapular position to investigate the effects of the positioner, test–retest reliability was estimated with a sample of 10 infants. The four measures—two with the infant on the positioner and two with the infant off the positioner—were completed twice in a 4-hour period. Pearson correlation coefficients between Time 1 and Time 2 ranged from .78 to .99; all but one coefficient were above .92. This pilot study indicated adequate reliability of this method of measuring **scapular rotation**.

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\(^1\) Manufactured by Hewlett Packard Medical Products Group, 3000 Minuteman Drive, Andover, Massachusetts 01810-1085.

### Table 1

**Estimated Gestational Age and Birth Weight of Subjects**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Infants</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestational age (weeks)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26–27</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>28–30</td>
<td>10</td>
<td>50</td>
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<td>31–33</td>
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<td>30</td>
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<tr>
<td>34–36</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Weight (g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 750</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>750–1000</td>
<td>1</td>
<td>5</td>
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<tr>
<td>1000–1250</td>
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<td>20</td>
</tr>
<tr>
<td>1250–1500</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>1500–1750</td>
<td>9</td>
<td>45</td>
</tr>
</tbody>
</table>

*Note. $n = 20$.*

### Positioner

A prone positioner was fabricated individually for each subject and designed to provide ventral support from the level of the clavicle to the hip. The positioner was fabricated from dense foam (.5 in. depth), with one side coated with adhesive. Two full-length rectangular thicknesses of the foam were cut and a third small rectangular piece of foam placed between the thicknesses in the area of the positioner that supported the upper trunk and shoulders. This third piece was designed to elevate the upper trunk and provide greater room for shoulder horizontal adduction. The length of the positioner equalled the length of the subject's trunk from the shoulder to the point of hip flexion, and the width was approximately the distance across the hips with a diaper in place. The three pieces of foam were adhered together, and two rounded cutout areas were made for the shoulders to allow for bilateral horizontal shoulder adduction (see Figures 1 and 2). These were estimated to begin midway between the sternoclavicular joint and the shoulder and round down to the level of the inferior scapular angle. The cutout areas allowed the subject to bring arms toward his or her face.

### Procedure

Each subject was observed for a total of six measurement sessions occurring over a 2-week period. Each session consisted of two 30-min periods in which the subject was positioned prone on the positioner (A) and prone without the positioner (B). The subjects were alternately assigned to a treatment sequence, resulting in 10 subjects in the AB sequence and 10 in the BA sequence.

Before the measurements, the subject was positioned by the examiner in either prone with the positioner or prone without the positioner and was left undisturbed for 5 min. After this adjustment period, the first measurements were taken. Measurements of heart rate, respiratory rate, and behavioral state were recorded at 0 min, 10 min, 20 min, and 30 min. The scapular rotation measures were...
performed and recorded at the beginning and end of each 30-min period. Immediately after the first 30-min period, the examiner repositioned the subject for the second treatment condition, and a second 5-min adjustment period commenced. Measures were then repeated in the same manner as the first treatment condition. Each of the six measurement sessions was separated by at least 1 day, and no more than three sessions occurred in a 7-day period.

**Results**

A three-way analysis of variance (ANOVA) with repeated measures was conducted for each dependent variable (i.e., heart rate, respiratory rate, behavioral state, four measures of scapular rotation). Sequence was a between-group factor, and both trial and use of positioner were within-group factors. Because sequence was never significant as either a main effect or an interaction, the two groups were pooled, and a two-way analysis of covariance for trial and positioner was computed, with behavioral state as the covariate.

The statistical analysis determined the influence of behavioral state on heart rate, respiratory rate, and scapular position when the subject was on and off the positioner. Behavioral state did not have a significant effect on these dependent measures; that is, when adjusted for behavioral state, the means for heart rate, respiratory rate, and scapular rotation were essentially the same. Therefore, the results are presented as a two-way ANOVA, using trial and positioner as factors.

Heart rate was found to differ only slightly between the two treatment conditions. Means of the two treatment conditions varied by 1.5 beats per min. This difference approached significance, $F = 4.04$, $df = 1, 19$, $p = .058$, although the difference was less than 1%. Heart rate did not change significantly over trials, $F = 1.07$, $df = 5, 95$, $p = .38$. Respiratory rate did not change significantly over trials, $F = 1.07$, $df = 5, 95$, $p = .38$. Respiratory rate did change significantly over trials, $F = 6.37$, $df = 5, 95$, $p < .001$. The rate was lower in the later measurement sessions when infants were of older gestational ages.

The four measures of scapular rotation were compared for the two treatment conditions. The differences in all measurements were significant, indicating that the presence of the prone positioner increased scapular upward rotation (see Tables 2 and 3).

For all 20 subjects, the distance between the superior medial scapular angles and the spine decreased and the distance between the inferior medial scapular angles and vertebral column increased when the positioner was used. This increased angle of scapular upward rotation was maintained for the entire period that the infant remained on the positioner. This scapular position was congruent with a position of shoulder flexion and horizontal adduction, bringing arms forward and toward midline.

**Discussion**

The purpose of this study was to determine whether a simple, inexpensive, individually fabricated prone positioner would improve scapular upward rotation and facil-
itate a hands-toward-midline position in the preterm infant without negatively affecting physiological stability. Researchers have emphasized the importance of measuring physiological parameters when evaluating the effectiveness and potential safety of a positioning method (Fox & Molesky, 1990; Heimler et al., 1992). Semmler (1989) specifically encouraged therapists who are using positioning tools in the NICU to evaluate how their handling and interventions influence physiological systems. The findings of no significant difference in heart and respiratory rates between the two methods of prone positioning in this study can allow some confidence that the introduction of the prone positioner did not negatively affect the subjects' physiological function. It was not expected, nor did the results suggest, that the presence of the positioner would provide a positive effect on heart rate and respiratory rate in addition to the effect documented for the prone position itself.

The importance of improving the neonate's scapular upward rotation as a preventive intervention has some support in the literature on both neonates and older infants. Because of global hypotonia and the tendency toward shoulder retraction (with scapular adduction), the preterm infant cannot easily achieve and maintain scapular upward rotation (with hands toward midline). Tightness of the scapular adductors and shoulder elevators has been documented clinically (Hunter, 1996) and seems to be related to static positioning that does not specifically promote flexed postures. Another associated effect of low postural tone is scapular winging, which is observed when infants are positioned in prone without support of their chests. Figure 3 depicts an infant at 26 weeks gestation age who is positioned in prone without the positioner. Scapular malposition is evident by the winged position of the scapula in relation to the rib cage. Support under the chest can facilitate scapular rotation and hands to midline. Figure 4 represents the same infant on the prone positioner, with the scapula resting on the rib cage in a position of upward rotation.

A position of scapular upward rotation and hands toward midline may positively influence a posture of overall flexor tone in the preterm infant (Barb & Lemons, 1989; Carter & Campbell, 1975; Hunter, 1996). Bly (1981) suggested that the presence of abnormal shoulder muscle tone can interfere with an infant's achievement of motor milestones. Preterm infants tend to have increased tightness in shoulder retraction in the first 18 months of life (Georgieff & Bernbaum, 1986). Therefore, it appears that scapular tightness, which develops in the neonatal period when the infant is relatively immobile, may not resolve in later infancy. The predominance of scapular retraction common in preterm infants (Hunter, 1996) can impede the performance of such skills as crawling, reaching, and manipulating in the infancy period (Georgieff & Bernbaum, 1986). Improvement of scapular upward rotation in the neonate may positively affect his or her achievement of midline reaching and manipulation of objects in the infancy period.

### Table 2

<table>
<thead>
<tr>
<th>Scapular Angle</th>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td></td>
<td>Left superior</td>
<td></td>
<td></td>
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<tr>
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<td>1.08</td>
<td>1.18</td>
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<td></td>
<td>SD</td>
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<td>(0.62)</td>
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<td>(1.17)</td>
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<td>3.20</td>
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<td>3.08</td>
<td>3.20</td>
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<td>SD</td>
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<td>(0.48)</td>
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<td>2.79</td>
<td>2.94</td>
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<td></td>
<td>SD</td>
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<td>(0.58)</td>
<td>(0.68)</td>
<td>(0.70)</td>
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<td>1.30</td>
<td>1.42</td>
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<td>(0.62)</td>
<td>(0.64)</td>
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<td>1.83</td>
<td>1.99</td>
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<td>SD</td>
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<td>(0.56)</td>
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<td>(0.69)</td>
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<td></td>
<td>Right inferior</td>
<td>2.84</td>
<td>2.95</td>
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<td>(0.41)</td>
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<td>(0.69)</td>
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Table 3
Analysis of Covariance of Scapular Measures With and Without the Prone Positioner

<table>
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<td>72.09</td>
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<td>Left inferior</td>
<td>7.77</td>
<td>.011</td>
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<tr>
<td>Right superior</td>
<td>103.94</td>
<td>.000</td>
</tr>
<tr>
<td>Right inferior</td>
<td>8.28</td>
<td>.000</td>
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*df= 18.

Although this study demonstrated benefits by comparing group means, in clinical practice, the neurobehavioral organization of each infant should be evaluated individually for appropriateness of the use of a prone positioner. The results of this study suggest that heart rate and respiratory rate are unaffected by the use of the positioner. However, this does not exclude the importance of vigilant monitoring of physiological response to any therapeutic intervention in the preterm infant.

Limitations

The sample was limited to the population of neonates who met criteria and were delivered at one NICU during a 4-month period. Generalizability is affected by the size of the sample and the limited distributions of birth weight, estimated gestational ages, race, and gender. The measure of scapular rotation only indirectly predicted a position of hands toward midline. The validity of the results would increase if arm and hand posturing were measured concurrently with scapular position. Measurements obtained in this study were compiled by the first author. Although test-retest reliability was evaluated, interrater reliability was not. Replication of the actual procedure and measurement by another researcher may produce differing results.

Directions for Future Research

Further study with regard to positioning infants in the NICU is needed. Three areas of research should be pursued before widespread clinical use of this positioner. An expansion of the subject group, with varying degrees of prematurity and developmental risk, would improve the generalizability of the results. In particular, replication of these results with a sample of infants who are more critically ill would increase the confidence with which this prone positioner could be used. Finally, research of the long-term effects of the use of a prone positioner on the preterm infant’s acquisition of motor milestones is needed. Both the timing and the quality of midline hand skills should be studied to ascertain whether improvements in scapular and shoulder position in the neonatal period are carried over into functional motor performance.

Conclusion

Therapists working in NICUs must evaluate the effects of any positioning intervention on the physiological systems of the neonate. It is of primary concern that intervention procedures pose minimal risks to the infant. The use of the prone positioner in this study improved scapular rotation without negative effects to the infant’s heart rate and respiratory rate. As such, it appears to be a safe intervention method that may prevent delays in development of midline hand skills among preterm infants.

Figure 3. Without the prone positioner, the shoulders are retracted and scapular winging is evident in this 26-week gestational-age infant.

Figure 4. The prone positioner was an effective method of providing external support to achieve and maintain scapular upward rotation in this infant, whose postural tone and motor development made the independent acquisition of that posture difficult.

Acknowledgments

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References


