The Effects of Swaddling Versus Standard Positioning on Neuromuscular Development in Very Low Birth Weight Infants

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ABSTRACT

A randomized control design was used to compare the effect of swaddling to standard positioning on neuromuscular development in very low birth weight (VLBW) infants (<1,250 gm). The outcome of neuromuscular development was measured at 34 weeks postconceptional age using the Morgan Neonatal Neurobehavioral Exam (MNNE).

The sample included 50 infants who met criteria for birth weight, age and who were classified as appropriate for gestational age. Exclusion criteria were also used. The infants were randomly assigned to the experimental group or the comparison group .

Data analysis included descriptive and inferential statistical techniques. The results demonstrated that swaddled infants had higher total scores on the MNNE as compared to infants with standard positioning.

Swaddling appears to be a positioning technique that can enhance neuromuscular development of the very low birth weight infant.

PRETERM BIRTH SUBJECTS the infant's neuromuscular development to the effects of positioning and gravity, often leading to nursery-acquired positional disorders.[1] At present, the focus of care is on early recognition and treatment of these disorders. A more effective approach would be an intervention to promote normal neuromuscular development in very low birth weight (VLBW) infants.

One possible intervention for the fostering of neuromuscular development is swaddling: the technique of wrapping the infant in a blanket to maintain the upper and lower extremities in flexion. This flexed position simulates the position *in utero*, where neuromuscular development is facilitated through weightlessness and containment in flexion.

This study compares the effects of swaddling to standard positioning on neuromuscular development in VLBW infants.

REVIEW OF THE LITERATURE

The intrauterine environment provides physical containment and weightlessness. If carried to term, the infant develops muscle tone and flexion in part because of the containment provided by the uterus. After preterm birth, however, the infant experiences prolonged immobilization on a firm mattress; the constant influence of gravity flattens the body surface against the mattress, producing nursery-acquired positional disorders.[1] Examples of these disorders include shoulder retraction; abduction of the hips, legs, and knees, resulting in the "frog leg" position of the lower extremities; and lateral flexion of the arms.

Motor development of the premature infant differs from that of the full-term infant even in the absence of diagnosed abnormality. The premature infant demonstrates consistent patterns of shoulder retraction, increased activity of the lower

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extremities, and dominance of extensor posturing. Bottos and Stefani reported that correct care for positioning and motor development can afford more mature movement and decrease the development of abnormal patterns of movement. Although they did not specifically define "correct care," Bottos and Stefani recommended positioning infants in flexion and symmetry using a hammock.[2]

In a study conducted by Updike and associates, interventions identified to reduce tonal abnormalities and positional disorders in the VLBW infant focused on helping the infant achieve movement into neutral flexion in prone, supine, and lateral positions.[3] Maintaining a flexed position may help improve flexor muscle tone and decrease extensor tone, thereby decreasing the effects of gravity on preterm muscle development. Flexion may also encourage self-quieting behaviors.[4]

Case states that the goals of positioning in the preterm neonate are to reduce the environmental stress of the neonatal intensive care unit (NICU) and to simulate the environment of the womb.[5] Updike and associates list five specific positioning goals: (1) to stimulate active flexion of trunk and limbs; (2) to achieve a more rounded head and active head rotation; (3) to encourage more balance between flexion and extension; (4) to allow for more symmetric posture to enhance midline orientation, contributing to eye-hand-mouth control; and (5) to facilitate smooth antigravitational movement.[3] Swaddling of the VLBW infant meets these positioning goals. However, there have been no studies to determine the effects of swaddling on neuromuscular development in VLBW infants.

Swaddling

Swaddling has been suggested as an intervention to provide proprioceptive input and kinesthetic stimulation, support hand-to-mouth maneuvers, and facilitate motor organization.[4-6] Frequent literature citations support swaddling as a means to calm irritable infants.[5-9] In addition, swaddling has been shown to decrease physiologic arousal, prolong daytime sleep states, and reduce pain-elicited distress in term infants.[7-11]

In the VLBW population, Als and associates utilized swaddling as one of the many strategies in an investigation of the individualized developmental care plan to reduce stress behaviors and increase self-regulatory behaviors of infants with bronchopulmonary dysplasia. As compared to the control group, the experimental group exhibited a decreased number of days on the ventilator, in oxygen, and before initiation of bottle feeding. In neurodevelopmental outcome, there was a significant difference between the two groups. The experimental group scored higher on developmental outcome as measured by the Assessment of Premature Infant Behavior (APIB) at one month postterm age and on the Bayley Scales of Infant Development at three, six, and nine months postterm age.[12]

Three major areas of care were addressed in Als's individualized care plan: (1) the physical distal and proximal environment of the infant; (2) direct caregiving; and (3) discharge planning. Swaddling was cited as an intervention focusing on bedding and clothing of the proximal environment of the infant. Although swaddling was not specifically cited as an intervention of direct caregiving, it could be utilized to provide the following direct caregiving interventions identified by Als: (1) shoulder and truncal support and foot bracing, both of which were specifically identified as interventions to aid in feeding; (2) support of flexor position to aid in transition facilitation; (3) boundaries and encasement as an intervention to promote sleep organization; and (4) firm containment of limbs to enhance organization of alertness. Although it is difficult to assess the specific impact that swaddling may have had on the outcomes of the individualized care plan, the maintenance of flexion provided by swaddling was significant to the goals listed in both the physical distal and proximal environment and the direct caregiving aspects of this study.

Risks associated with swaddling have been reported. Rabin and colleagues found that dislocation of the hip was more common in Navajo infants who had been swaddled on a cradleboard.[13] Chisholm found that if a preexisting congenital hip dislocation was present, swaddling on a cradleboard exacerbated the condition by limiting the ability to maintain the legs in flexed position.[14] In Turkey, swaddling in extension and in the supine position is being examined as a potential risk factor in the higher incidence of pneumonia in that country.[15] Bundling infants in warm environments has also been reported as an exogenous cause of fever.[16]

The operational definitions of swaddling used in those studies that reported risks associated with swaddling differed greatly from the opera-

tional definition of swaddling used in this study. Specifically, swaddling in this study did not entail wrapping in extension, maintaining the infant in supine position, or using multiple blankets in an increased environmental temperature.

Little is known regarding the effects of swaddling as a positional intervention in VLBW infants. Conceptually, swaddling would appear to promote the development of VLBW infants by simulating the *in utero* position. However, as swaddling has not been studied as a positional intervention for this purpose, this study compares the effects of swaddling versus standard positioning on neuromuscular development in VLBW infants. Based on the literature and on our clinical impressions, two hypotheses were posed:

1. There will be a significant difference between swaddled infants and standard-position infants in flexed posture and in flexor tone of the extremities as measured by the Morgan Neonatal Neurobehavioral Exam (MNNE) at 34-weeks postconceptional age.
2. There will be a significant difference between swaddled infants and standard-position infants in overall behavior response as measured by the MNNE at 34-weeks postconceptional age.

Hypotheses were tested at the $p = .05$ level.

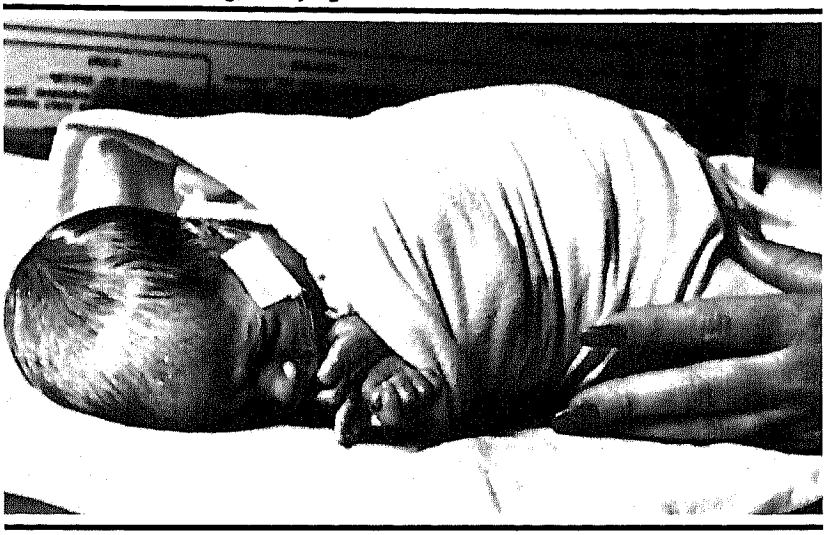
METHODS

Operational Definitions

Swaddling was defined as wrapping an infant in a blanket to maintain upper and lower extremities in flexion with hands positioned near the mouth (Figure 1). A hip roll was used to provide flexion when infants were in prone position unless the infant exhibited signs of respiratory distress. Swaddling was used in prone, supine, and lateral positions. The infants were repositioned by the nursing staff every two to four hours. Staff unwrapped the infants when necessary for nursing or medical assessment and intervention. In addition, the infants were unwrapped as desired by parents when visiting. Infants in this group were swaddled at least 15 hours per day.

Standard positioning was defined as routine nursery position. Infants were positioned prone, lateral, and supine. Blanket rolls were used to help them maintain position. The nursing staff repositioned the infants every two to four hours, depending on how they tolerated handling.

FIGURE 1 ■ Swaddling, side-lying.



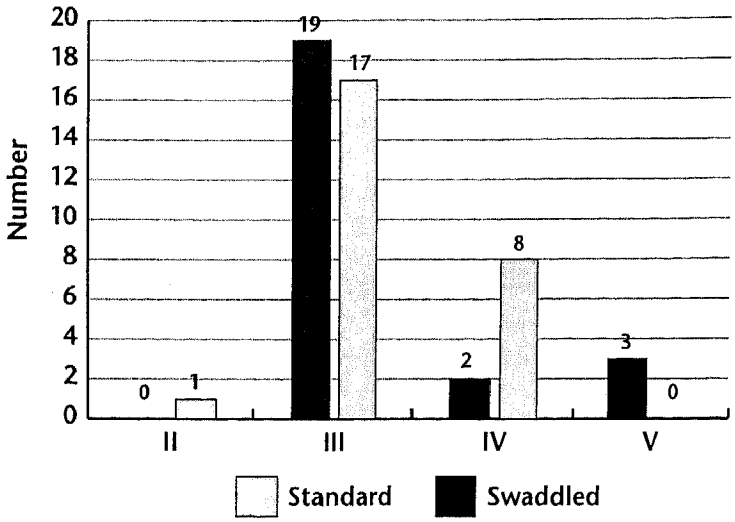
Standard-position infants were swaddled when necessary for irritability or thermoregulation. Infants in this group were swaddled less than eight hours per day.

Neuromuscular development was measured by the scores on the MNNE administered at 34-weeks postconceptional age. The MNNE is a quantitative assessment of neonatal neurologic status. It has been used in the clinical setting, but it has also been recommended as a research tool for early outcome measures.[17] The MNNE consists of 27 items divided into three sections: (1) tone and motor patterns, (2) primitive reflexes, and (3) behavior responses. Each section has nine items, each scored on a 3-point scale. The maximum possible score is 81, indicating appropriate neurobehavioral gestational maturation of an infant >36-weeks postconception. The minimum score possible is 27, reflecting neurobehavioral gestational maturation of an infant <32-weeks postconception.[18]

Sample

The setting of this study was a 27-bed NICU at a large urban teaching and referral hospital. The study was reviewed and approved by the institutional review board. The inclusion criteria for the study were (1) birth weight <1,250 gm, (2) appropriate for gestational age as determined by the staff neonatologist, (3) at least 7 days of age but not more than 21 days of age, (4) approval of staff neonatologist, and (5) written informed consent by the parents or legal guardian. Exclusion criteria were (1) any congenital anomalies, (2) intraventricular hemor-

FIGURE 2 ■ Neonatal medical index score of subjects.



rhage (IVH) Grade III or IV as determined by ultrasonography, (3) seizure activity, (4) umbilical venous or arterial catheters, (5) peripheral artery catheters, and (6) phototherapy.

Prior to initiating the study, a *t*-test was used to calculate a sample size of 25 subjects per group at a power of 80 percent. A sample of 50 infants was obtained over a two-year period. A consecutive sampling strategy for infants who met the inclusion-exclusion criteria was employed. Subjects were assigned to either the experimental group (swaddling) or the comparison group (standard positioning) by use of a computer-generated table of random numbers.

The sample consisted of 50 preterm infants who were divided equally by gender: female 25 and male 25. Race distribution was Caucasian 32 (64 percent), African American 17 (34 percent), and biracial 1 (2 percent). There were no statistically significant differences among the groups on the variables of race and sex.

The medical acuity of the subjects was measured using Neonatal Medical Index (NMI) scores. The NMI was developed as an indicator of the medical course of a premature infant with birth weight <1,500 gm. The tool is predictive of later cognitive and motor development. The range of the NMI is from I, indicating a preterm infant with no medical complications (no respiratory distress, assisted ventilation, oxygen, patent ductus, or apnea/bradycardia), to a V, indicating a preterm infant with the most severe medical complications (29 or more days of assisted ventilation, meningitis, seizures, IVH Grade III or IV, or periventricular leukomalacia).[19] The majority of subjects had index scores of III or IV. The major difference between an index score of III and a score of IV was the length of time the infant remained on assisted ventilation. The NMI scores did not differ significantly between groups. The distribution of subjects by score is shown in Figure 2.

Baseline characteristics and other variables were assessed in both groups to check for confounding variables and group differences. The variables examined included birth weight, gestational age in weeks, length of stay, discharge weight, number of days with oxygen therapy, and minutes visited per day. The groups did not differ significantly on any of the variables. Table 1 shows the mean and standard deviations for the variables assessed for both groups.

Procedure

Upon meeting the study criteria, subjects were randomly assigned to either the experimental group (swaddling) or the control group (standard positioning), as described previously. Incubators of participating infants were marked "swaddling" or "standard positioning" to indicate group assignment. The staff nurses in the NICU swaddled the infants in the study. A mandatory inservice was held prior to the initiation of the study. This inservice included a video on how to swaddle, a demonstration of swaddling, and provided nurses with an opportunity to swaddle an infant correctly. The use of a hip roll was also explained and demonstrated.

Research assistants or the principal investigator or both made daily checks to monitor the protocol. In addition, the infants in the control group were monitored daily to ensure that they

TABLE 1 ■ A Comparison of Swaddled and Standard-Position Infants in Mean and Standard Deviation of Baseline Characteristics and Other Variables

	Birth Weight (gm)	Gestational Age (weeks)	Length of Stay (days)	Discharge Weight (gm)	Days Ventilated	Days in O_2	Minutes Visited per Day
Swaddled	1,072.2 ± 122.7	28.0 ± 1.5	54.8 ± 16	1,900 ± 108.54	7.9 ± 15.7	22.2 ± 24.7	58.6 ± 23.3
Standard position	1,008 ± 153.8	27.7 ± 1.6	58.6 ± 17	1,942 ± 134.4	4.8 ± 9.4	31.7 ± 29	57.3 ± 30.3

TABLE 2 ■ Mean Scores and Standard Deviation of the MNNE for Swaddled and Standard-Position Infants Based on Wilcoxon Rank Sum Analysis

Mean (SD)	Tone & Motor Subscale	Primitive Reflexes Subscale	Behavioral Responses Subscale	Total Score
Swaddled n = 24	21.83 (3.07) $p = .0261$	21.29 (2.34) $p = .0596$	19.04 (2.59) $p = .0427$	61.74 (6.44) $p = .0073$
Standard position n = 26	19.61 (3.75)	19.78 (3.01)	17.69 (2.32)	56.81 (6.50)

were not being swaddled except for irritability or thermoregulation. The bedside data collection sheet was completed by the NICU staff nurses on a daily basis. The presence of a ventilator; FiO_2; minutes visited; weight; hours prone, lateral, and supine; and hours swaddled were recorded on the sheet. The nurses were provided an inservice on data collection prior to the initiation of the study, and a pilot study of ten infants was done to familiarize the staff with this instrument.

Measurements of neuromuscular development of swaddled and standard-position infants were obtained at 34-weeks postconceptional age using the MNNE. Data collection for the MNNE was performed by one of three occupational therapists, who were blinded to group assignment. The examination was done in a parent room in the NICU 30 minutes prior to the infant's feeding time. The first five MNNEs and every tenth MNNE were scored simultaneously by all three occupational therapists to assess for interrater reliability. Greater than 80 percent agreement criterion was maintained.

FINDINGS

Infants in the experimental group were swaddled $\overline{X} = 21.1$, SD = 0.68 hours per day, as compared to infants in the control group, who were swaddled $\overline{X} = 1.6$, SD = 1.3 hours per day. The scoring of the MNNE produces data that are not normal or ratio level in nature; therefore, the Wilcoxon Rank Sum was used for statistical analysis. The swaddled infants scored statistically higher on tone and motor subscale $p = .03$, behavior response subscale $p = .04$, and total score $p = .007$. The mean and standard deviation scores from the MNNE are reported in Table 2.

The data were analyzed again with deletion of high- and low-acuity subjects, as determined by NMI scores. Infants with an index score of II (n = 1) and an index score of V (n = 3) were deleted. The swaddled infants scored statistically higher on tone and motor subscale, $p = .01$; primitive reflex subscale, $p = .02$; behavior response subscale, $p = .008$; and total score, $p = .002$. The mean and standard deviation scores for both groups on the MNNE after deletion of the high- and low-acuity subjects are reported in Table 3.

DISCUSSION

The results of this study suggest that swaddling in flexion enhances neuromuscular development in infants who are neurologically intact. The data support the first research hypothesis: There is a significant difference between swaddled and standard-position infants in flexed posture and in flexor tone of the extremities as measured by the MNNE at 34 weeks postconceptional age. Swaddling in flexion conceptually simulates the position *in utero,* which promotes the hypertonicity of the term infant by confining the infant in flexion. The tone and motor subscale of the MNNE evaluates change in active and passive tone of the preterm infant. As scores increase on the scales of 1–3, there is a change from extension to flexion. Swaddled infants

TABLE 3 ■ Mean Scores and Standard Deviation of the MNNE for Swaddled and Standard-Position Infants with Deletion of High- and Low-Acuity Subjects Based on Wilcoxon Rank Sum Analysis

Mean (SD)	Tone & Motor Subscale	Primitive Reflexes Subscale	Behavioral Responses Subscale	Total Score
Swaddled n = 21	22.05 (3.2) $p = .0134$	21.81 (1.97) $p = .0205$	19.62 (2.06) $p = .0078$	63.00 (5.75) $p = .0017$
Standard position n = 25	19.52 (3.80)	19.88 (3.02)	17.68 (2.38)	56.80 (6.63)

scored statistically higher on this subscale, indicating improved flexed posture and flexor muscle tone.

The data also support the second hypothesis: There was a significant difference between swaddled and standard-position infants in overall behavior responses as measured by the MNNE at 34-weeks postconceptional age. Swaddling in flexion conceptually allows for improved symmetrical posture and midline orientation. This in turn allows for better eye-hand-mouth control, facilitating self-quieting activities. The behavior response subscale evaluates this conceptual framework by assessing responsiveness, temperament, and equilibration. The swaddled infants' statistically higher scores on the behavior response subscale $p = .04$ indicate an increased ability to process and respond to external stimuli, a higher threshold to noxious stimuli, and a quicker return to emotional baseline after the stimulation threshold has been exceeded. The data support swaddling as a positioning technique to improve overall behavior response in VLBW infants.

After deletion of the high- and low-acuity patients, the data further support both hypotheses but also provide an unexpected finding. The swaddled infants had statistically higher scores on the primitive reflex subscale $p = .04$. Because reflexes are a developmental process of the central nervous system, we did not anticipate that a positioning intervention could enhance their development. However, in reviewing the scoring of the MNNE, we found an explanation. The subscale was scored as follows: A score of 1 indicated absence of the reflex; a score of 2 indicated partial demonstration of a reflex; a score of 3 indicated a brisk reflex. Reflexes in the neonate, unlike those in the older child and in the adult, reflect both muscle tone and central nervous system development.[20] Swaddled infants scored statistically higher on the tone and motor subscale, reflecting improved flexor tone, and this may have elicited higher scores from the evaluators on the primitive reflex subscale. Because swaddled infants demonstrated improved flexor muscle tone, they may have been better able to demonstrate the presence of a reflex.

Because position can have a physiologic impact on the neonate, it was important to monitor the effects of position on the outcome of the swaddling intervention. The staff nurses who provided both interventions were given latitude to position both the swaddled and the standard-position infants in prone, lateral, or supine position at their discretion. To maintain flexion in prone position, a hip roll was encouraged for both groups. The mean hours per day in prone position were 18.2 for both groups. In lateral position the mean hours per day were 3.5 for swaddled infants and 2.8 for the control group. In supine position the figures were 1.2 hours and 1.5 hours, respectively. There was no significant difference in time spent in each position between the two groups.

An important limitation of this study is the exclusion of infants with Grade III or IV intraventricular hemorrhage. In addition, if at one month of age ultrasonography indicated evidence of periventricular leukomalacia, the subject was deleted from the study. Therefore, the conclusions of the study apply only to VLBW infants who are neurologically intact.

The study is also limited by the fact that there is no accurate tool for assessing gestational age for infants with birth weights <1,500 gm.[21] Date of last menses and results of early prenatal ultrasound were used to determine gestational age.

A third limitation is the potential lack of control over the amount of flexion in the swaddling group. The staff nurses were instructed to wrap the infants in full flexion and to assess for maintenance of flexion at each vital sign assessment. Additionally, some nurses served as research assistants who monitored swaddled infants for full flexion every eight hours. However, because of differences between individual nurses, the amount of flexion when swaddled may have varied. Furthermore, the staff nurses who cared for the subjects were aware of group assignment; therefore, the potential of a Hawthorne effect did exist.

Recommendations for Further Research

Although swaddling is cited frequently as a nursing intervention,[5-9] there are few empirical data for the VLBW population. Further research should include the long-term implications of swaddling and the potential risks of swaddling for this population.

IMPLICATIONS FOR NURSING PRACTICE

The results of this study have important implications for nursing practice. Because neuromuscular developmental delay is a significant problem for VLBW infants, interventions that promote neuromuscular development must be incorporated into their nursing care. The findings of this study support swaddling as one such intervention for preterm infants who are neurologically intact.

Swaddling is an easily provided, inexpensive, and widely available intervention. It has other known benefits, which have been reported in the literature: Swaddling calms irritable infants, promotes physiologic stability, and reduces pain-elicited distress.[5-9] Because swaddling maintains the infant in a flexed position, it may provide VLBW infants with other benefits associated with flexion: midline orientation, eye-hand-mouth control, and increased self-quieting behaviors.

With the current technology, the risks of swaddling VLBW infants seem small. Dislocation of the hip, increased incidence of pneumonia, and exogenous fever as reported in the literature do not appear to be risk factors for swaddling as the term is operationally defined in this study.

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