Stable Preterm Infants Gain More Weight and Sleep Less after Five Days of Massage Therapy

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Objective   To examine the effects of 5 days of massage therapy on the weight gain and sleep/wake behavior of hospitalized stable preterm infants.   **Methods**   Massage therapy (body stroking/passive limb movement for three 15-minute periods per day) was provided to 16 preterm neonates (mean gestational age, 30.1 weeks; mean birth weight, 1359 g), and their weight gain, formula intake, kilocalories, stooling, and sleep/wake behavior were compared with a group of 16 control infants (mean gestational age, 31.1 weeks; mean birth weight, 1421 g).   **Results**   The massage group averaged 53% greater daily weight gain than the control group. The massage group spent less time sleeping at the end of 5 treatment days than the control group and more time in the drowsy state.   **Conclusions**   Healthy, low-risk preterm infants gained more weight and slept less with just 5 days of massage, in contrast to 10 days in previous studies. Results support the continued use of massage as a cost-effective therapy for medically stable preterm infants.

Key words   preterm infants, massage therapy, weight gain, behavior.

Over the last half century, numerous studies have reported that premature birth is associated with neurodevelopmental impairment that is inversely proportional to the gestational age and birth weight of the infant (Bhutta, Cleves, Casey, Cradock, & Anand, 2002). Early postnatal difficulties include problems with autonomic nervous system control, behavioral state organization, and attention (Doussard-Rossevelt, Porges, & McClenny, 1996; Perlman, 2001). Problems during infancy and early childhood include auditory and visual deficits as well as delays in cross-modal transformations and sensorimotor integration (Herrgard, Karjalainen, Martikainen, & Heinonen, 1995; Luoma, Herrgard, & Martikainen, 1998; Samson & de Groot, 2001), motor deficits such as abnormal reflexes, diminished intraoral sucking, hypotonia, impaired postural control and gross motor coordination, and inferior hand use, as well as difficulties with language acquisition (Craig, Grealy, & Lee, 2000; Gorga, Stern, Ross, & Nagler, 1991; Jennische & Sedin, 1998; van der Fits, Flikweert, Stremmelaar, Martijn, & Hadders-Algra, 1999).

Longitudinal studies indicate that developmental problems persist into adolescence and include neuropsychological deficits such as lower IQs, poorer auditory discrimination, impaired articulation and diminished word fluency, attention-deficit disorders, and learning disabilities (Bhutta et al. 2002; Cherkes-Julkowski, 1998; Jennische & Sedin, 2001; Kok, den Ouden, Verloove-Vanhorick, & Brand, 1998; Lane, Attanasio, & Huselid, 1994; Tideman, 2000), as well as emotional and behavioral problems such as hyperactivity, internalizing, and conduct disorders (Chapieski & Evankovich, 1997; Schothorst & van Engeland, 1996; Stjernqvist & Svenningsen, 1999).

Researchers have provided hospitalized preterm infants with various forms of supplemental stimulation in an effort to enrich the environment of the neonatal intensive care unit (NICU) or to accelerate development (Dieter & Emory, 1997; Feldman & Eidelman, 1998). One of the most widely studied interventions has been massage therapy (Vickers, Ohlsson, Lacy, & Horsley, 2000). A number of studies have shown that the 10-day massage therapy

protocol introduced by Field and her colleagues (1986) promotes weight gain in preterm infants (Ferber et al., 2002; Jinon, 1996; Kuhn et al., 1991; Scafidi et al., 1990; Scafidi et al., 1986; Wheeden et al., 1993). The average daily weight gain in these studies was 28% to 47% greater in the massaged groups despite similar formula and caloric intake.

The 10-day massage therapy protocol also alters the distribution of sleep and awake states. Across studies, the massaged preterm infants spent more time in active alertness and showed better performance on the Brazelton exam at the end of the treatment period (Field, Scafidi, & Schanberg, 1987; Scafidi et al., 1986, 1990; Wheeden et al., 1993). Furthermore, the massaged preterm infants were discharged between 3 and 6 days sooner than control infants, accounting for lower hospital costs.

The first 10-day massage study by Field and colleagues (1986) suggested that the weight gain advantage for the massage group first emerged after 5 days of treatment. The goal of the current study was to examine the effects of 5 days of massage therapy on the weight gain and sleep/awake behavior of preterm infants. Showing that an abbreviated protocol is beneficial warrants the continued use of massage therapy for hospitalized preterm infants who are being discharged earlier from intermediate care nurseries and at lighter weights.

Method
Participants

Participating infants were recruited from a large inner-city hospital. Preterm infants were eligible for participation if: (a) their gestational age (GA) was between 25 and 34 weeks as assessed by an evaluation at delivery of passive tone and physical maturity (i.e., Dubowitz score) and as documented by prenatal medical records; (b) their birth weight was between 750 and 1600 g; (c) their birth weight was appropriate for their gestational age (AGA). Discrepancies between pre- and postnatal information regarding GA were ruled in favor of the decision made after birth by the attending neonatologist.

Infants with medical conditions primarily related to immaturity, such as respiratory distress syndrome, hyaline membrane disease, apnea, elevated bilirubin, and mild hypoglycemia and hypocalcemia, were not excluded. All of the infants in the study graduated from the NICU to the intermediate care nursery and had received comparable courses of treatment including oxygen and phototherapy, antibiotics, and intravenous/gavage feedings (see Table I). Preterm infants were specifically excluded if: (a) they exhibited genetic anomalies, congenital heart mal-

formations, and/or central nervous system dysfunction; (b) they were HIV-positive; (c) there was a history of maternal drug use (by drug screen); (d) they required surgery; (e) there was any evidence of intraventricular hemorrhage on ultrasound examination; or (f) they were breast-fed. Those few infants who were breast-fed were excluded so that daily kilocalorie intake could be accurately calculated.

A computer program (Dubin, 1990) was used to conduct a power analysis for two independent groups based on the between-group means and standard deviations of the Field et al. (1986) study. Findings suggested 6 participants per group were necessary for 95% power to detect the effect of massage therapy on weight gain ($p = .01$, two-tail). We increased the group size to allow for potential attrition and to have a reasonable participants-to-variables ratio.

Prior to recruitment, informed consent was obtained from the parents and the attending physician. The study had full institutional review board approval from the university's school of medicine. We attempted to recruit all infants who fulfilled the inclusion/exclusion criteria. The ratio of available to assigned infants was roughly 4 to 1. It was our experience that informed consent was usually obtained if the study was discussed with parents when they visited the unit. That so few infants were successfully recruited reflected primarily a failure to obtain written informed consent because of the relative scarcity of parental visits. We do not believe that health status played a role in whether parents agreed to provide consent, since all of the infants were medically stable and in the final stage of their hospital stay at time of recruitment.

A random stratification procedure was used to assign infants to either the massage therapy group ($n = 16$) or the control group ($n = 16$). All infants were medically stable and were not receiving IV fluids, oxygen, phototherapy, antibiotics, or gavage feeds at the start of the study.

On average, infants were approximately 3 weeks old at assignment. All were born to mothers of lower socioeconomic status. There were 11 (68.75%) male infants in the massage therapy group and 9 male infants (56.25%)in the control group. Nine massage infants were African American (56.25%), 5 were Hispanic (31.25%), and 2 were white (12.50%). Ten control infants were African American (62.50%), 5 were Hispanic (31.25%), and 1 was white (6.25%).

Measures and Procedure

The massage therapy protocol used by Field et al. (1986) was also used for this study. Massage therapy was begun on the day following study assignment, and it was continued for 5 consecutive days. As in previous studies, the

Table I.   Means (*SD*) for the Preassignment Variables

Measures	Massage	Control	*p* Value
Maternal age	26.9 (4.8)	28.1 (5.6)	0.52
Parity	2.0 (0.9)	2.7 (1.6)	0.23
Gestational age, weeks	30.1 (2.5)	31.1 (2.8)	0.30
Birth weight, g	1359.3 (140.1)	1421.5 (91.9)	0.20
Ponderal index[a]	2.1 (0.3)	2.2 (0.3)	0.30
Apgar 1 minute	6.7 (1.7)	7.4 (1.3)	0.20
Apgar 5 minutes	8.1 (0.8)	8.4 (0.6)	0.36
Obstetric complications[b]	68.7 (14.7)	70.7 (9.9)	0.67
Postnatal complications[b]	75.1 (6.6)	74.9 (5.3)	0.93
NICU days	20.4 (12.3)	18.9 (12.2)	0.74
Days O_2 therapy	2.8 (1.6)	3.5 (1.7)	0.23
Days-to-gavage feeds	1.9 (1.5)	2.3 (0.8)	0.39
Days antibiotics	4.2 (1.0)	4.5 (1.8)	0.52
Days phototherapy	3.7 (1.4)	4.4 (1.1)	0.13
Days since birth	25.6 (11.7)	22.0 (5.8)	0.29
Assignment weight	1655.1 (89.9)	1621.2 (54.4)	0.21
Assignment head circumference, cm	30.0 (1.2)	29.7 (1.1)	0.52
Preassignment weight gain, 1 day, grams	29.9 (14.0)	25.3 (11.9)	0.21
Preassignment formula intake, 1 day, cc	225.7 (51.9)	211.3 (34.0)	0.36
Preassignment kilocalories, cc/kg/d	149.5 (30.6)	135.2 (27.1)	0.36
Preassignment bowel movements, 1 day, number	1.9 (0.9)	2.0 (0.5)	0.63

[a]Ponderal index = birth weight/length^3 × 100.

[b]Higher score is optimal.

NICU = neonatal intensive care unit

first 15-minute massage occurred approximately one hour after the morning feeding, the second about one half hour after the midday feeding, and the third approximately 45 minutes after the completion of the second stimulation period.

Each treatment session consisted of 5 minutes of tactile stimulation, followed by 5 minutes of kinesthetic stimulation, and concluded with another 5-minute period of tactile stimulation. The therapist warmed his/her hands prior to the start of treatment and remained silent during the 15-minute interval.

During tactile stimulation, the infant was placed prone and was given moderate pressure stroking with the flats of the fingers of both hands. Five one-minute intervals, consisting of six 10-second periods of stroking, were applied to the following body regions: (a) from the top of the infant's head, down the back of the head to the neck and back to the top of the head; (b) from the back of the neck across the shoulders and back to the neck; (c) from the upper back down to the buttocks and returning to the upper back (contact with the spine was avoided); (d) simultaneously on both legs from the hips to the feet and back to the hips; (e) both arms simultaneously from the shoulders to the wrists to the shoulders.

For the kinesthetic phase, the infant was placed in a supine position. Each of the five one-minute segments consisted of six passive flexion/extension movements lasting approximately 10 seconds each. These "bicycling-like" movements of the limbs occurred in the following sequence: (a) right arm, (b) left arm, (c) right leg, (d) left leg, and (e) both legs simultaneously.

During massage therapy, the infant's reaction to stimulation was monitored continuously for signs of adverse events. Furthermore, intermediate care nursery personnel (i.e., physicians, nurses, and staff) were in constant attendance. Behavioral observation focused on the occurrence of signs of distress (e.g., yawning, finger splaying, crying), and physiologic reaction was monitored through heart rate and respiration rate. Because significant behavioral distress (e.g., crying) often leads to physiologic overreactivity in preterm infants, physiologic measures were used to assess adverse treatment responses. At the sign of physiologic distress (i.e., heart rate greater than 200 bpm), massage was discontinued for 15 seconds, or until a return to baseline levels was observed. Massage was then resumed. Auditory alarms warned of excessive physiologic reactivity. The occurrence of five periods of physiologic overreactivity was arbitrarily chosen as the criterion for discontinuing an infant from the study. No infant who received massage therapy needed to discontinue participa-

tion due to an adverse treatment response. Furthermore, no infant in either group experienced any significant medical complications during the course of participation.

Due to recent changes in the intermediate care nursery, preterm infants are discharged earlier following their transfer from the NICU. Therefore, the formal assessment of massage therapy effects was limited to 5 treatment days. The majority of the infants were discharged immediately after completing the study or shortly thereafter. This earlier discharge policy prohibited any direct comparison between 5 and 10 treatment days or an evaluation of the lasting effects of massage therapy after its conclusion.

Obstetric and postnatal complications were summarized on the Obstetric and the Postnatal Complications Scale comprised of items related to pregnancy, birth, and postnatal events (Littman & Parmelee, 1978). Higher scores are optimal on both measures.

Nursing notes were examined daily for weight gain, volumetric input, number of bowel movements, and medications. Kilocalories (i.e., cc/kg/d) were calculated each day using the standard formula based on the day's volumetric intake and caloric content of the formula. Formula caloric content was prescribed by each infant's attending physician and remained constant throughout participation. Chi-square analysis revealed no group difference on the number of infants receiving 20 or 24 calories per ounce formula.

Daily weight gain was measured in the early morning by nurses on the preceding night shift. Group assignment was not documented in the infants' charts, in an effort to conceal participation. Regardless, it was likely that some nurses knew which infants were enrolled in the study and to which condition they were assigned. It has been our experience that such knowledge has little effect on how the infants are treated during their time in the study. None of the enrolled infants received supplemental rocking from hospital volunteers.

During each day of participation, the number of family visits was documented. Family visits usually consisted of the parent(s) holding and feeding the infant. The two groups did not differ on the frequency of family visits.

Observations of sleep/awake patterns are useful for studying the neurobehavioral organization and development of both preterm and full-term infants. Research indicates that during the preterm period, there is a significant decrease in active sleep and a significant increase in quiet sleep and quiet and active waking, as well as greater temporal organization of sleep/awake patterns (Holditch-Davis & Edwards, 1998a, 1998b; Ingersoll & Thoman, 1999).

Sleep/awake behaviors were coded via live observa-

tions at the same time (i.e., between the morning and midday feeds) on the preassignment and last days of the study. We used the same approach established by Field and colleagues for their previous massage therapy studies (e.g., Scafidi et al., 1986, 1990). Observations are designed to be representative of the daytime behavioral organization of preterms residing in the intermediate care nursery. With the exception of early evening (when the majority of parental visits occur), the nursery's schedule is quite consistent given that preterm infants receive around-the-clock care. That both observations occurred at the same time of day controlled for the potential effects that circadian rhythm or environmental factors (e.g., reduced lighting at night) have on preterm infant behavior. Furthermore, Day 5 observations occurred approximately 90 minutes after the day's first massage, thus allowing sufficient time for any immediate treatment effects on behavior to subside.

A standardized behavior coding system was used that included the following states: (1) non-REM sleep; (2) active sleep without REM; (3) REM sleep; (4) drowsy; (5) quiet alert; (6) active alert; (7) crying (Thoman, 1975). The 30-minute observations were recorded on a laptop computer using a program that records the percent time (% time) the infant spent in each behavior state. Observers were trained to 85% interrater.

In order to increase statistical power, the sleep/awake behavior states were combined as follows: (a) *sleep,* including States 1, 2, and 3; (b) *awake,* comprising States 5, 6, and 7; (c) *quiet,* consisting of States 1, 4, and 5; and (d) *active,* including States 2, 6, and 7. Because of the transitional quality of drowsiness, that state was excluded from the sleep/wake categories but was included in the quiet category. Since REM sleep can occur with or without motor activity, that state was excluded from the quiet or active categories.

Results

Data analyses revealed no differences between groups on sex or ethnicity. Furthermore, the two groups did not differ in hospital treatment course or on the assignment day variables (see Tables I and III).

A repeated-measures analysis of variance (massage therapy vs. control) yielded a significant group main effect for weight gain, $F(1, 30) = 13.91$, $p = .001$ (see Figure 1). On average, the massage therapy group ($M = 48.7$ g, $SD = 36.9$) gained 26 g more per day than the control group ($M = 22.7$ g, $SD = 12.2$). Univariate tests revealed that the massage therapy group gained significantly more weight than the control group on the first [$F(1, 30) = 4.64$, $p =$
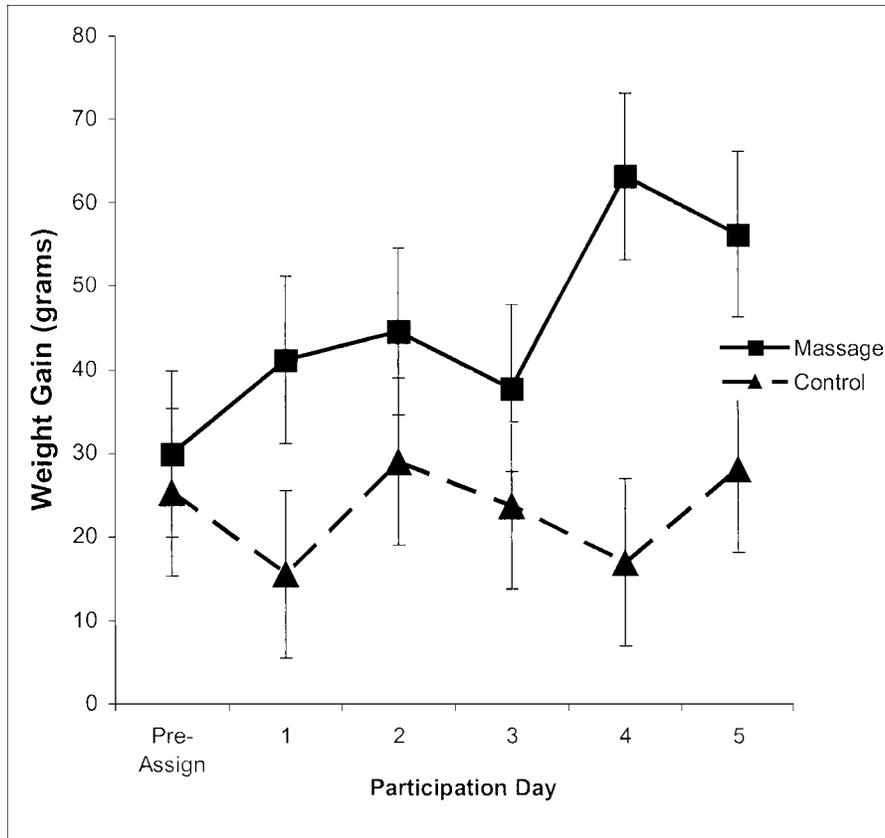
Figure 1.   Weight gain between massage therapy and control infants.

.04] and fourth [$F(1, 30) = 6.48$, $p = .02$] days of participation. Daily formula and kilocalorie intake, number of bowel movements, and number of family visits did not differ across groups (see Table II).

Examination of the distribution of total weight gain values across both conditions revealed one statistical outlier in the massage therapy group ($z = +3.59$) and one in the control group ($z = -2.20$). Removal of the outliers and reanalysis failed to yield any statistically significant changes to the uncorrected findings.

A repeated-measures multivariate analysis of variance (massage therapy vs. control) yielded a significant group by day effect for state organization from the first to the last day of participation, $F(3, 28) = 3.21$, $p = .04$ (see Table

III). Univariate tests revealed that the massage therapy group spent less time sleeping on the last day than the control group (M % time: 53.0, $SD = 37.7$ vs. 81.1, $SD = 34.5$), $F(1, 30) = 4.81$, $p = .04$. Post hoc analysis of the seven constituent states revealed that the massage therapy group spent more time in the drowsy state than the control group (M % time: 16.8, $SD = 19.3$ vs. 2.5, $SD = 3.8$), $F(1, 30) = 8.45$, $p = .007$ (see Table IV).

Discussion

These findings support previous studies showing that massage therapy promotes weight gain and alters the distribution of sleep/awake states in preterm neonates. Those

Table II.   Means (*SD*) for Clinical Measures

Measures	Massage	Control	*p* Value
Mean total weight gain, g	243.5 (184.5)	113.5 (60.7)	0.03
Mean daily weight gain, g	48.7 (36.9)	22.7 (12.2)	0.01
Mean daily formula intake, cc	239.7 (55.1)	231.0 (40.1)	0.62
Mean daily kilocalories intake, cc/kg/d	160.6 (36.9)	154.8 (26.9)	0.62
Mean daily number of bowel movements	2.3 (0.9)	1.9 (1.0)	0.33
Mean daily number of family visits	0.8 (0.9)	0.6 (0.4)	0.37

Table III.   Percent-Time Means (*SD*) for Behavioral State Categories

	Massage		Control	
	Preassignment Day	Day 5	Preassignment Day	Day 5
Sleep[a]	80.0 (30.1)	53.0 (37.7)*	86.2 (25.4)	81.1 (34.5)
Awake[a]	12.7 (21.6)	30.1 (34.5)	9.1 (23.1)	16.4 (31.6)
Quiet[b]	72.2 (21.0)	61.1 (21.6)	61.5 (24.5)	56.6 (27.3)
Active[b]	19.3 (17.8)	27.1 (19.3)	24.6 (22.2)	26.4 (22.5)

[a] Summation of the sleep and awake categories will not equal 100% since State 4 (i.e., drowsy) is not included in either category.

[b] Summation of the quiet and active categories will not equal 100% since State 3 (i.e., REM sleep) is not included in either category.

*$p = .04$.

receiving massage showed a 53% greater average daily weight gain compared with the control infants. The massaged preterms in the current study showed a greater daily weight gain with just 5 days of massage, in contrast to the 10 days in prior studies.

As in previous investigations, the current study found no significant differences between the massage therapy and control groups on formula or kilocalorie intake. Using an animal model, Uvnas-Moberg, Widstrom, Marchini, and Winberg (1987) proposed that tactile stimulation heightens vagal activity, which stimulates the release of food absorption hormones that facilitate weight gain. Field and Schanberg (1995) evaluated this model in human preterms and found that massage therapy increased vagal tone and was associated with a 62% rise in insulin release. Currently, we are examining the effects of preterm infant massage therapy on insulin-like growth factor I and oxytocin, two peptide hormones that play a role in weight gain and may be stimulated through heightened vagal activity.

In the previous 10-day studies, the massage therapy groups spent more time in the awake and active states (e.g., Scafidi et al., 1986, 1990). Five days of massage therapy also led to a significant reduction in sleep states and an increase in drowsiness. The reduction in sleep noted in the massage group can be viewed as a positive effect. A recent treatment model suggests that once preterm infants are medically stable, supplemental stimulation should be initiated to promote the preterm infant's engagement

Table IV.   Day 5 Percent-Time Means (*SD*) for the Constitute Behavioral States

State	Massage	Control	*p* Value
Quiet sleep	33.1 (32.4)	51.2 (31.2)	0.12
Active sleep	8.3 (8.2)	12.9 (10.3)	0.17
REM sleep	11.7 (13.9)	17.0 (21.5)	0.42
Drowsy	16.8 (19.3)	2.5 (3.8)	0.007
Quiet awake	11.3 (17.8)	2.9 (9.4)	0.11
Active awake	13.1 (15.9)	4.1 (9.2)	0.61
Crying	5.8 (12.8)	9.4 (21.4)	0.56

with caregivers and the environment (Dieter & Emory, 1997). Along with the statistically significant increase in drowsiness, trends shown by the massage therapy infants may reflect acceleration in the developmental course of sleep/wake patterns in preterm infants (see Table IV). A larger sample is needed to confirm whether 5 days of massage therapy promotes the development and organization of sleep/wake patterns in preterms. A comparison with 10 treatment days would be useful to determine the dose-response relationship between massage therapy and behavioral state development.

Since the early findings of Levine (1959, 1960; Levine & Mullins, 1966), animal studies have shown that supplemental stimulation or environmental enrichment accelerates development. The "handling" paradigm has been widely applied in these investigations. Studies consist of the experimenter separating the animal from its mother and holding it for a period of time. Handled rats have been shown to demonstrate less fear in novel situations, greater exploratory behavior, better performance during stressful challenges, lower emotional reactivity, greater weight gain, and even superior cognitive, learning, and memory performance in old age (e.g., Ader, Friedman, Grota, & Schaefer, 1968; Fernandez-Teruel, Escorihuela, Driscoll, Tobena, & Battig, 1991; Gonzalez, Rodriguez Echandia, Cabrera, Foscolo, & Fracchia, 1990; Meaney, Aitken, Bhatnagar, van Berkel, & Sapolsky, 1988). Studies have also shown that handled rats secrete less corticosterone in adulthood than do nonhandled rats, exhibit permanent increases in hippocampal glucocorticoid receptors, and show lower levels of corticotropin-releasing factor and plasma adrenocorticotropin following stressful challenges (e.g., Meaney et al. 1988; Meaney, Aitken, Sharma, Viau, & Sarrieau, 1989; Meaney, Aitken, & Sapolsky, 1987; Plotsky & Meaney, 1993). Many of the effects of handling on animals appear similar to those observed in human preterm infants receiving massage, including greater weight gain, fewer stress signs, and superior performance on challenging neurobehavioral examinations. Therefore, procedures such as massage therapy may in-

oculate the preterm infant against stress and promote general adaptation, presumably through their impact on the hypothalamic-pituitary-adrenal axis. While preliminary findings suggest that massage therapy reduces cortisol levels in human preterm infants (Acolet et al., 1993), further investigations are needed to support the validity of the animal model.

Regardless of positive research findings, massage therapy has not been widely adopted on NICUs (only 38% of nurseries use massage, based on a recent national survey [Field, in press]).This reflects a "minimal touch" policy that still is maintained by many neonatologists and NICU staff (Morrow, Field, Scafidi, Roberts, & Eisen, 1991). The frequently cited study by Long, Alistair, Philip, and Lucey (1980), who observed that procedures such as feedings, diaper changes, and examinations were sometimes associated with significant decreases in transcutaneous oxygen saturation ($tcPO_2$), is often used to support this minimal touch policy. The widespread acceptance of this view has hindered the introduction of procedures that are beyond standard nursery care.

Despite continuing controversy regarding the safety of massaging preterm infants, at least nine studies have demonstrated the safety of massage therapy for grower nursery infants, including Morrow and colleagues (1991), who reported that preterm infants exhibited clinically safe $tcPO_2$ levels across massage therapy sessions. Infants in the current study were closely monitored during massage therapy. None exhibited notable physiologic overreactivity and no infant was dropped from the study due to adverse events.

With regard to clinical guidelines, massage therapy may start whenever the preterm infant is deemed medically stable by the attending physician. Thereafter, the individual response of the infant to massage therapy should guide the course of treatment. We are currently enrolling infants who are between 1000 and 1100 g at time of recruitment. Some of these infants are even lighter at birth. Infants may be residing in either the NICU or grower nursery. Infants residing in the NICU no longer have main lines for IV feeds and antibiotics since that would prohibit administration of the standardized protocol.

Although the 5-day/weight gain results of this study require replication, they support the continued use of massage as a cost-effective therapy for grower nursery preterm infants. That the promotion of weight gain was so rapid suggests that the dose-response ratio may be lower than previously thought.

Acknowledgments

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