VAGAL ACTIVITY, GASTRIC MOTILITY, AND WEIGHT GAIN IN MASSAGED PRETERM NEONATES

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Objective   Multiple studies have documented an increase in weight gain after 5 to 10 days of massage therapy for preterm neonates. The massaged preterm neonates did not consume more calories than the control neonates. One potential mechanism for these effects might involve massage-induced increases in vagal activity, which in turn may lead to increased gastric motility and thereby weight gain.

Study design   The present randomized study explored this potential underlying mechanism by assessing gastric motility and sympathetic and parasympathetic nervous system activity in response to massage therapy (moderate pressure) versus sham massage (light pressure) and control conditions in a group of preterm neonates.

Results   Compared with preterm neonates receiving sham massage, preterm neonates receiving massage therapy exhibited greater weight gain and increased vagal tone and gastric motility during and immediately after treatment. Gastric motility and vagal tone during massage therapy were significantly related to weight gain.

Conclusion   The weight gain experienced by preterm neonates receiving moderate-pressure massage therapy may be mediated by increased vagal activity and gastric motility. *(J Pediatr 2005;147:50-5)*

Randomized, controlled studies have consistently documented greater weight gain in preterm neonates receiving massage therapy (also known as tactile/ kinesthetic stimulation).[1-3] Preterm neonates receiving 5 to 10 days of massage therapy exhibited a 21% to 47% greater increase in weight gain during the study period and were hospitalized for 3 to 6 days less than control neonates receiving standard care. The question of how massage therapy facilitates weight gain in preterm neonates remains unanswered. One hypothesis was that massage leads neonates to consume more calories. However, preterm neonates who received massage did not consume more formula or calories than the control preterm neonates.[4-9] Another hypothesis was that massaged neonates conserved more calories by increasing sleeping time. However, the massaged neonates were more alert and spent more time in active awake states than control neonates, suggesting that enhanced weight gain was not achieved by decreased activity.[8]

A third hypothesis is that moderate-pressure massage stimulates vagal activity, leading to more efficient food absorption through increased gastric motility and the release of food absorption hormones, such as insulin.[10] This hypothesized mechanism is based on our work demonstrating increased vagal activity and insulin levels in preterm neonates after massage therapy,[10] on a rat model showing that moderate-pressure stroking is critical for stimulating the release of ornithine decarboxylase (an index of growth hormone),[11,12] and on both rat and human models showing that stimulation of pressure receptors in the intraoral cavity increases vagal activity and the release of food absorption hormones.[13]

We examined this potential mechanism by assessing indices of vagal activity and gastric motility in preterm neonates receiving moderate-pressure massage therapy. Based on previous findings and on our proposed pressure receptor stimulation model, we hypothesized that preterm neonates receiving moderate-pressure massage therapy would show greater weight gain and increased vagal activity and gastric motility, but not greater calorie intake than preterm neonates receiving light-pressure stimulation (sham/ placebo massage) or controls.

CSI	Cardiac sympathetic index		EGG	Electrogastrogram
CVI	Cardiac vagal index		IBI	Interbeat interval
ECG	Electrocardiogram			

METHODS

Participants

After approval by the institutional review board of the University of Miami School of Medicine and parental consent, medically stable preterm neonates were recruited from the University of Miami/Jackson Memorial Hospital Neonatal Intensive Care Unit. Neonates were excluded from this study if they (a) required surgery; (b) received respiratory support, antibiotics, or phototherapy; (c) had genetic anomalies, congenital heart malformations, and/or central nervous system dysfunction; or (d) were HIV-positive or immunocompromised or (e) if their mothers had a history of syphilis, hepatitis B, or alcohol/illicit drug use. At study entry, all neonates were gavage-fed. There were no systematic differences in diagnoses between treatment groups.

A total of 115 preterm neonates met our inclusion criteria. Of these, 61 had parents who could not be contacted (n = 55) or refused to participate in the study (n = 6). Due to equipment malfunctions and unusable data, 6 neonates (3 control, 2 massage, and 1 sham) were excluded from the study. Our final sample comprised 48 hospitalized preterm neonates who were assigned to a control (n = 16), massage therapy (n = 16), or sham massage therapy group (n = 16) based on stratified randomization based on birth weight and a permuted block design based on a computer-generated randomization list and a 1:1:1 allocation ratio implemented to attain equal treatment group sizes.

Data collection was done by researchers blind to the neonates' group assignments. Parents and clinical staff were also blind to the neonates' group assignments and to the hypotheses of the study. Massage therapists were blind to the hypotheses of the study. Power analyses based on our previous neonatal vagal tone study suggested that a minimum of 10 to 15 participants per group would be needed to detect vagal tone differences between groups (80% power; $P < .05$; 2-tailed test).

Throughout this 5-day massage therapy study, relevant medical history was gathered, and mean weight gain per day per neonate weight, mean calories consumed per day per neonate weight, and days from beginning of treatment to discharge (days to discharge) were recorded. Electrocardiograms (ECGs) and electrogastrograms (EGGs) were collected during the first treatment session (control/ massage/sham) of the study for a total of 45 minutes (15 minutes baseline, 15 minutes treatment, and 15 minutes posttreatment) at approximately the same time for all subjects (between 1:00 and 3:00 PM) 1 hour after feeding. All subjects continued to receive standard nursery care during the course of the study.

Treatment Groups

Treatment was provided for 3 15-minute periods per day for 5 days, 1 hour after feeding by massage therapists trained in the study protocol. Training involved presentation of a structured video treatment protocol followed by a series of observation and practice sessions. Reliability was assessed by the authors before study commencement and reevaluated throughout the study period to ensure protocol compliance, especially with respect to the amount of pressure provided. Each neonate received treatment from several therapists to ensure that treatment effects were the result of the treatment protocol and not from any one particular therapist. Therapists providing the light-pressure sham massage did not perform moderate-pressure massage therapy and vice versa.

The massage therapy consisted of the 15-minute preterm neonate massage therapy protocol used by Field et al.[5] The 15-minute stimulation sessions included 3 standardized 5-minute phases, with tactile stimulation in the first and third phases and kinesthetic stimulation in the middle phase. In the tactile stimulation phase, the neonate was placed in a prone position and stroked with moderate pressure (sufficient to produce a slight skin color change from pink to white in a Caucasian neonate or slight indentations in the skin for all neonates). The neonate is massaged for 5 1-minute periods (12 strokes at approximately 5 seconds per stroking motion) over each region in the following sequence: (1) from the top of the head to the neck and back to the top of the head, and back to the neck; (2) from the neck across the shoulders; (3) from the upper back to the waist and back to the upper back; (4) from the thigh to the foot to the thigh on both legs; and (5) from the shoulder to the hand to the shoulder on both arms. During the kinesthetic stimulation phase, the neonate is placed in a supine position and each arm, then each leg, and finally both legs together are flexed and extended (as in a bicycling motion). Each flexion/extension motion lasts 10 seconds, for a total of 5 1-minute segments.

The light-pressure sham massage followed the same Field et al[5] protocol. The scheduling and duration of the sham and massage therapy sessions were identical in the type, number, and rate of movements, with the exception that light-pressure stroking (producing no skin color change in a Caucasian neonate or skin indentation for all neonates) was used during the first and last 5-minute periods of the sham massage procedure. The middle 5-minute period of kinesthetic stimulation remained the same. The sham massage procedure served as a pressure stimulation control condition.

Physiological Measures

An ECG was obtained from each neonate using a UFI Model SRS2004/d-SP Electrophysiology Acquisition System (UFI, Morro Bay, CA) to derive measures of heart rate and autonomic nervous system function. ECGs were acquired by placing 3 disposable silver chloride electrodes on the neonate's chest and back. The signal was filtered between 1 Hz and 100 Hz, amplified using a gain of 2000, and sampled at a rate of 1000 Hz. After manual artifact correction, ECG data were converted to R-wave intervals (interbeat intervals [IBIs]) to the nearest millisecond using data acquisition and analysis software (Acq Knowledge software, version 3.5; Biopac Systems,). IBI data were then analyzed using CMETI software[14] (freeware written by J.J.B. Allen, Department of Psychology, University of Arizona, Tuscon, AZ) to obtain measures of sympathetic nervous system activity (cardiac