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Effects of One-Month Baby Massage by Mothers on Autonomic Nervous System Function and Growth Development of 4- and 5-Month-Old Infants

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ABSTRACT

Background: Massage has been practiced since around 3 months of age for the purpose of interacting with children, but there are few reports on its ongoing effectiveness, no unified views, and few reports on growth and development.

Purpose: The purpose of this study was to examine the effects of massage given by mothers to their 3-month-old infants based on autonomic activity and growth development of 4- and 5-month-old infants one month later.

Methods: The subjects were healthy 3-month-old infants and their mothers who were born as full-term, singleton babies. The study design was an inequivalent control group design: 25 mother-child pairs were massaged for one month and 12 mother-child pairs were not massaged. Data were collected twice, once on the first day at 3 months of age and one month later. As indicators of autonomic nervous system activity, axillary temperature before and after massage, heart rate and heart rate variability during massage were measured. As an indicator of growth, body weight was measured after the massage. As an indicator of development, mothers were asked to respond to a questionnaire (KIDS). The axillary temperature, rate of change in heart rate and heart rate variability, and KIDS scores were compared on the first day and one month later.

Results: Axillary temperature and LF/HF ratio of children at 1 month were significantly lower after massage ($p<0.05$). Overall developmental age and expressive language domain of KIDS at 1 month were more developmental than in the non-massage group ($p<0.05$). Heart rate and HF were not significantly different after 1 month.

Conclusion: It was found that when children received massage from their mothers for one-month, cardiac sympathetic nerve function was suppressed and the development of expressive language skills was promoted.

Keywords: *baby massage; autonomic nervous system function; heart rate variability*

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BACKGROUND

At around 3 months of age, infants develop visual and auditory senses, respond to human voices, follow others, babble, and laugh when being soothed. Baby massage begins around 3 months of age, when the baby's head is almost fully formed, and is offered in many institutions for the purpose of interacting with the child. Physiological indicators of mothers who massage their children include decreased salivary cortisol levels (Mitani et al., 2012; Tanaka et al., 2014), decreased salivary amylase levels (Okumura et al., 2011), and decreased pulse rate (Nomachi et al., 2013; Okumura et al., 2011). Psychosocial indicators include improved mood (Ito et al., 2016; Mitani et al., 2012; Tanaka et al., 2014), feelings toward children (Ito et al., 2016; Okumura et al, 2011), depressive tendency (Ito et al., 2016), childcare anxiety and childcare stress (Mitsumori et al, 2009), and improved responsiveness to children (Lee, 2006), and reduced fatigue (Fujita et al., 2006) have been reported. On the other hand, it has been reported that mothers with infants around 4 months of age do not get the hang of caring for their infants and are unfamiliar with childcare (Kitoh et al., 2021; Mistry et al.,2007).

Infant massage, during which mothers stroke their infant's skin slowly and gently, is a type of tactile stimulation. The practice of infant massage varies across the world with western cultures adapting some of the traditional practices from eastern cultures. Physiological and psychological impact of infant massage reviews of the effectiveness of infant massage have to date focused on preterm infants. Studies have shown that preterm infants who received massage therapy had greater weight gain (Liao et al., 2021) and a significantly lower length of hospitalization than control preterm infants (Gonzalez et al., 2009). In fullterm infant, physiological indicators of infants at 3-4 months of age who received massage while growing and developing in this manner include a decrease in salivary cortisol concentration (Nomachi et al., 2013), a decrease in salivary amylase concentration, an increase in trunk and hand-fist body surface temperature, and a decrease in pulse rate (Okumura et al., 2011). In infants 2-7 months of age, an increase in the high frequency (HF) is seen at a massage rate of 7.5 cm/s (Kamiya et al, 2021), and in 3-4 month old full-term infants born as low birth weight infants, weight gain is seen after 1 month (Lestari et al, 2021). Reports on psychosocial measures include increased reactivity after 4 weeks of massage in 2- to 6-month-olds (Lee et al, 2006) and increased scores on "social," "cognitive and adaptive," "language," and "social domain" in 9-month-olds who received massage for 6 months (Saitoh et al, 2002). However, there was no difference in weight gain of 1-month-olds who received massage for 24 days (Abedi, 2018), and no difference in mean mental development index and psychomotor development index scores in 3-to 6-month-olds who received massage for 2 months compared to the infants with non-received massage (Liu, 2001). The effects of massage on infants' growth and development are not clear.

OBJECTIVE

The purpose of this study was to examine the effects of massage on autonomic nervous system function and growth and development in 4- and 5-month-old infants one month after receiving massage from their mothers.

METHODS

1. Study design

Non-equivalent control group design study

2. Study subjects

The subjects of this study were single fetuses born after 37 weeks of gestation with a birth weight of 2,500 g or more, paired with their mothers, and who had passed the first 3 months of life and were doing well thereafter. Of these, 25 pairs of mothers and children who voluntarily participated in baby massage classes were considered as the massage group. On the other hand, 12 pairs of mothers and children of the same age who visited the pediatrician for immunization and did not plan to attend the baby massage class were the non-massage group.

3. Survey period

January 2013 - December 2013

4. Intervention method

4.1) Massage group

Posters requesting cooperation for participation were posted at one obstetrics and gynecology clinic that held baby massage classes, and a survey cooperation request form was distributed to mothers who had reservations to attend classes. On the first day of the baby massage class, the purpose, goals, methods, ethical considerations, and cooperation in the household survey were explained in writing and orally, and consent forms were obtained.

4.2) Non-massage group

Posters requesting cooperation for participation were displayed in pediatric clinics where vaccinations were offered. When 3-month-old children and their mothers visited the clinic for immunization, a survey cooperation request form was distributed. The researcher explained the purpose, goals, methods, ethical considerations, and cooperation of the family survey in writing and orally, and obtained written consent5.

5. Details of the intervention

Mothers were to massage their children daily for approximately 15 minutes for one month. The time of massage was left up to the mother and was explained to stop immediately after breastfeeding, 48 hours after immunization, during fever, and if the child did not want to be massaged.

6. Intervention methods

On the first day of attending the 3-month postpartum massage class, mothers were instructed by a certified baby massage instructor on massage techniques, procedures, and precautions, and massaged their infants using oil. The oil was 100% natural, fragrance-free, and color-free jojoba oil, and a patch test was conducted prior to the massage to ensure that neither the child nor the mother had any allergies. The child was massaged by the mother on the legs, abdomen, chest, back, and upper extremities in that order.

7. Measurements

7.1) Indices of autonomic nervous system function in both Massage group and Non-massage group

7.1). (1) Axillary temperature

Body temperature is a regulatory mechanism that keeps the temperature of the central nervous system and deep organs in the optimal range. Maintenance of body temperature is important for growth and development due to stabilization of respiration (Ibarra, 2008) and metabolic caloric expenditure associated with reduced oxygen consumption (Mathews,2018). By 4 days of age, the peripherally warmed blood of the newborn is delivered to the center of the body by cutaneous vessels innervated by the sympathetic nervous system to maintain deep body temperature homeostasis (Ohkawa, 2005). Because body temperature fluctuates during the day, and at 3-6 months of age, body temperature at night is lower than during the day and reaches a maximum around 10 am (Nanakida, 2017), measurements were taken before and after massage from 1-4 pm, when fluctuations are minimal. An electronic thermometer (electronic thermometer C230 Terumo), which can measure equilibrium temperature in approximately 20 seconds, was used for the measurements, considering the burden and safety of the children. Room temperature and humidity were measured using a digital thermo-hygrometer (TT532 Tanita).

7.1). (2) Heart rate and heart rate variability

The heart is under the dual autonomic control of the cardiac sympathetic nervous system and the parasympathetic cardiac vagus nerve. Heart rate fluctuates depending on environmental factors acting on the autonomic nervous system. HF range of heart rate variability is 0.15-0.4 Hz and is an indicator of cardiac parasympathetic function. The low-frequency (LF) range is 0.04-0.15 Hz, and the LF/HF ratio represents the balance between sympathetic and parasympathetic nerves and is an indicator of cardiac sympathetic function (Shimizu, 2006; Sakaguchi et al., 2006), and unpleasant emotions increase the LF/HF ratio due to increased sympathetic activity (Sato, 2006). There is a negative (Kohara, 2001) and positive (Oku, 2005) relationship between heart rate and heart rate variability. Heart rate and heart rate variability were measured from before the start to the end of the massage using a memory heart rate monitor (memory heart rate monitor LRR-03 Arm Electronics, Inc.) with electrode pads placed at three locations on the chest. The obtained data were subjected to frequency analysis using a real-time heart rate variability analysis program (MemCalc / Bonaly Light, Suwa Trust Company).

7.2) Evaluation of growth and development in both Massage group and Non-massage group

7.2). (1) Developmental age

Developmental age was assessed using the Kinder Infant Development Scale (KIDS), developed by Miyake et al. in 1990. The KIDS has four different types of questionnaires (A, B, C, and T), type A for healthy subjects from 1 to 11 months of age, type B for those from 12 months to 35 months of age, type C for those from 3 years to 6 years and 11 months of age, and type T for the disabled patients (Miyake et al. 1990). In our subjects from 4 to 5-month-old infants, we used Type A, consisting of 117 questions, and domain profile consists of motor, manipulative, comprehension language, expressive language, adult and social skills, and eating. Caregivers observed the infant's daily activities and answered the questions with a circle or a cross. Overall developmental age was determined from the total score of all domains using a conversion table. Reliability and validity were assessed using the retest method (Hashimoto et al.,2012)

7.2). (2) Body weight

Weight is one of the indicators of physical growth of infants, and was measured on the first day of massage before the intervention and one month after the intervention, both

in massage classes and at participants' homes. A digital baby scale (fanection 1584 Tanita) was used to measure weight, and researchers measured naked infants before massage.

7.3) Basic Attributes

Maternal age, pregnancy history, pregnancy and delivery status, infant weight at birth and one month later, gender, Apgar score, and body size category were collected.

8. Data collection methods

8.1) Massage group

Surveys were conducted twice, once on the first day of participation in the massage class before the intervention and once after the one-month intervention, the first time at the massage class and the second time at home. The child's weight was measured before the massage, body temperature was measured before and after the massage, and heart rate and heart rate variability were measured from before to the end of the massage. During the approximately 15-minute massage, the mother's posture and voice were left to the mother, and the child wore only a diaper during the massage. Information on the mothers' pregnancy, delivery, the postpartum period, and the progress of the newborn was collected from the mother-child health handbook and orally. The second survey was measured in the same way as the first.

8.2) Non-massage group

Surveys were conducted twice, once at the first visit to the pediatrician for immunization (first day) and again approximately one month later. Measurements were taken at each subject's home as in the massage group, but instead of massage, participants held their clothed children. The mothers were free in posture and voice for approximately 15 minutes while holding their children and remained normal during the one-month study period. The second survey was measured in the same way as the first.

9. Analytical methods

KIDS scores and axillary temperatures before and after massage on the first day and one month later were compared using paired t test or Wilcoxon signed-rank test. Heart rate and rate of change in heart rate variability during massage were calculated based on values before the start of massage, and the two groups were compared by two-sample test or Mann-Whitney U test. The statistical package software PASW Statistics23 for Windows was used for analysis, with a statistical significance level of $p<0.05$.

10.Ethical Considerations

This study was conducted with the approval of the Ethics Committee of Shiga University of Medical Science (Approval No. 22-151). Consent was obtained from the subjects that participation in this study was voluntary, that no benefits or disadvantages would result from their participation or non-participation, that this study could be discontinued, and that the personal information and data obtained would not be used for any purpose other than this study. Mothers in the non-massage group who requested massage were offered the massage method after the study was completed.

RESULTS

1. Subject demographics

The child-mother pairs who participated in this study were 25 in the massage group and 12 in the non-massage group. The birth weight of the massage group was 3009 ± 387 g and 6288 ± 691 g at 3 months, while the birth weight of the non-massage group was 3085 ± 3534 g and 5863 ± 653 g at 3 months. In the massage group, 18 (72.0%) were first-time mothers and 7 (28.0%) were postpartum mothers. In the non-massage group, 6 (50.0%) were first-time mothers and 6 (50.0%) were postpartum mothers, with no

difference between the two groups (see Table.1).

Table 1. Characteristics of the Subjects

Item		Massage group (n=25)	Non-massage group (n=12)	P value
Child				
Weight (g)	At birth	3,009±387	3,085±354	0.57 [a]
	At 3 months (first day)	6,288±691	5,862±653	0.08 [a]
Gender	Male	8 (28)	8 (67)	0.05 [c]
	Female	17(72)	4 (33)	
Feeding method	Breast milk	19 (76)	8 (67)	0.35 [c]
	Mixed	5 (20)	3 (25)	
	Artificial	1 (4)	1 (8)	
Mother				
Age (years)		31.6±4.7	32.2±7.0	0.76 [a]
history of delivery	first birth	18 (72)	6 (50)	0.17 [b]
	having borne children	7 (28)	6 (50)	
Working	Yes	10 (40)	4 (33)	0.49 [b]
	On parental leave	9 (90)	4 (100)	
	No	15 (60)	8 (67)	

Figures are persons (%) or mean ± standard deviation
[a] Two sample t test
[b] Fisher's exact test
[c] Chi-square test

2. Comparison of axillary temperatures before and after massage on the first day and one month later

On the first day, the axillary temperature of the massage group significantly increased from 36.7±0.3°C before massage to 37.1±0.3°C after massage (p=0.00) and also significantly increased from 36.6±0.3°C before massage to 37.0±0.3°C after massage one month later (p=0.00). On the other hand, in the non-massage group, there was no difference between before and after the first and second hug (see Table.2). The mean room temperature and humidity for both groups at the time of measurement did not differ between the first day and one month later (see Table.3).

Table 2. Infant body temperature before and after massage on the first day of massage and one month later

	Massage group			Non-massage group			Massage group vs non-massage group P value	
	Before	After	P value	Before	After	P value	Before	After
First day	36.7±0.3	37.1±0.3	0.00 [a]	36.7±0.3	36.6±0.2	0.37 [a]	0.97 [b]	0.00 [b]
After 1 month	36.6±0.3	37.0±0.3	0.00 [a]	36.6±0.2	36.4±0.2	0.05 [a]	0.78 [b]	0.00 [b]

Figures are mean ± standard deviation
[a] Paired t test
[b] Wilcoxon signed rank test

Table 3. Room temperature and humidity on first day of massage and one month later

	First day			One month later		
	Massage group	Non-massage group	P value	Massage group	Non-massage group	P value
Room temperature (°C)	24.4±0.6	24.0±0.7	0.05	24.1±1.2	23.7±0.8	0.29
Humidity (%)	57.2±8.8	57.0±10.7	0.96	57.5±7.8	56.6±8.4	0.76

Figures are mean ± standard deviation
Two sample t-test

3. Comparison of the rate of heart rate change and heart rate variability during massage in children on the first day and after one month3

The average heart rate and each heart rate variability value were calculated separately before and during the massage (from the start to the end of the massage). The rate of change in the average heart rate and each heart rate variability value was calculated by dividing the difference in the average heart rate or each heart rate variability value before and during massage by the average heart rate or each heart rate variability value before massage. Percent change in LF/HF ratio during massage at 1 month was -0.44% in the massage group and 0.11% in the non-massage group (p=0.01) . There were no differences in heart rate and HF at 1 month and in heart rate and heart rate variability on the first day (see Table.4).

$$Hr(Hrv)= \frac{AverageHeartRate\ (Hrv)\ during\ massage\ —\ AverageHeartRate(Hrv)before\ massage}{AverageHeartRate(Hrv)before\ massage} \times 100$$

Table 4. Heart rate and heart rate variability on the first day of massage and one month later

	First day			One month later		
	Massage group	Non-massage group	P value	Massage group	Non-massage group	P value
Heart rate (bpm)	0.10 (-0.48, 0.04)	0.01 (-0.11, 0.07)	0.86 [b)]	-0.02 (-0.07, 0.04)	0.03 (-0.04, 0.09)	0.13 [b)]
HF (ms^2)	-0.05 (-4.04, 0.42)	-0.02 (-0.53, 0.32)	0.77 [b)]	0.17 (-0.38, 0.63)	-0.78 (-1.76, 0.20)	0.06 [a) #]
LF/HF (%)	-0.31 (-0.71, -0.09)	0.12 (-0.92, 0.46)	0.08 [b)]	-0.44 (-0.66, -0.10)	0.11 (-0.49, 0.45)	0.01 [b)]

Numbers are medians (quartiles 25th percentile, 75th percentile)
[#] Tests using means
[a)] Two sample t test
[b)] Mann-Whitney test

4. Comparison of developmental age at day 1 and month 1

The massage group showed significant differences after one month compared to the first day in all domains: motor (p=0.00), manipulative (p=0.00), comprehension language (p=0.00), expressive language (p=0.01), social (p=0.00) and eating (p=0.01). The overall developmental age was 4.0 months (IQR 4.0, 5.0) on the first day and 6.0 months (IQR 5.0, 6.0) after one month, a significant difference (p=0.00). On the other hand, the non-massage group showed significant differences after one month compared to the first day in three domains: manipulative (p=0.03), comprehension language (p=0.04), and social (p=0.03). Significant differences in overall developmental age were found at 4.0 months (IQR 3.3, 4.8) on the first day and 5.0 months (IQR 4.0, 6.0) on the second day (p=0.01). However, no differences were found in the three domains of exercise, expressive language, and diet (see Table.5).

Table 5. KIDS score of infants on first day of massage and one month

	Massage group			Non-massage group			Massage group vs Non-massage group P value	
	First day	One month later	P value	First day	One month later	P value	First day	One month later
Overall developmental age (Month)	4.0 (4.0, 5.0)	6.0 (5.0, 6.0)	0.00 [b)]	4.0 (3.3, 4.8)	5.0 (4.0, 6.0)	0.01[b)]	0.19 [d)]	0.02 [d)]
Motor area (Month)	3.0 (3.0, 5.0)	5.0 (4.0, 6.0)	0.00 [b)]	3.0 (3.0, 3.0)	3.0 (3.0, 4.0)	0.19 [b)]	0.07 [c)]	0.00 [d)]
Operating Area (Month)	4.0 (3.0, 4.0)	5.0 (4.5, 5.0)	0.00 [b)]	3.0 (2.3, 4.0)	4.0 (3.0, 4.0)	0.03 [b)]	0.04 [c)]	0.00 [d)]
Comprehension Language Domain (Month)	6.0 (5.0, 6.0)	7.0 (6.0, 7.0)	0.00 [b)]	4.5 (4.0, 6.8)	6.0 (5.0, 7.0)	0.04 [b)]	0.33 [d)]	0.25 [d)]
Representation Comprehension Area (Month)	6.0 (4.0, 6.5)	7.0 (6.0, 7.0)	0.01 [b)]	5.5 (4.0, 7.0)	6.0 (6.0, 7.0)	0.06 [b)]	0.93 [d)]	0.48 [d)]
Social domain (Month)	3.0 (3.0, 5.0)	5.0 (4.0, 6.5)	0.00 [a) #]	3.0 (3.0, 4.8)	5.5 (3.3, 6.8)	0.03 [a) #]	0.94 [d)]	0.78 [c)]
Meal area (Month)	4.0 (3.0, 4.0)	4.0 (4.0, 6.0)	0.01 [b)]	3.5 (3.0, 4.8)	4.0 (4.0, 6.0)	0.14 [a) #]	0.89 [d)]	0.73 [d)]

Numbers are medians (quartiles 25th percentile, 75th percentile)
Tests using means
[a)] paired t test
[b)] Wilcoxon signed rank test
[c)] Two sample t test
[d)] Mann-Whitney test

5. Comparison of children's weight gain per month

The average weight gain per month was 22.0 g in the massage group and 22.5 g in the non-massage group, showing no difference (see Table.6).

Table 6. Percentage of infants gaining weight after one month

	Massage group	Non-massage group	P value
Weight gain (%)	20.0 (13.5, 25.5)	22.5 (15.2, 34.4)	0.65

Numbers are medians (quartiles 25th percentile, 75th percentile)
Mann-Whitney test

DISCUSSION

1. Assessment of autonomic nervous system function

Both on the first day and one month later, axillary temperatures of infants who received massage from their mothers increased significantly after the massage. The body temperature of newborns in an optimal temperature environment is regulated by skin vasomotion (Ohkawa, 2005), and brown adipose tissue produces heat and maintains body temperature when the environmental temperature is low (Saitoh, 2020). Because the children in the massage group wear only diapers before the massage, they receive a cold stimulus on the skin surface, unlike the children in the non-massage group. This stimulation increases sympathetic nerve function and constricts skin blood vessels, thereby inhibiting heat dissipation. As the infant begins to receive massage, the skin vessels, warmed by frictional heat, flow into the center of the body, maintaining body temperature. As the body temperature rises, heat is dissipated out of the body through dilation of skin vessels and increased blood flow (Kanosue, 2010). As the infant continues to receive massage, the infant becomes more physically active, increases locomotion, stimulates metabolism, and raises body temperature. As the infant's temperature rises, sympathetic nervous system activity is suppressed and heat is dissipated through dilation of skin vessels and increased blood flow. Although the infant is naked until dressed after the massage, heat dissipation may have increased the infant's axillary temperature. Okumura et al. (2011) reported that a single massage increased body surface temperatures of the trunk and palms of the hands in infants aged 3 to 5 months with similar results. Receptors that sense skin temperature are activated in the brain and lymphocytes when the temperature rises above 36°C (Kanosue, 2010), and are transmitted from the skin through the spinal cord and brainstem to the preoptic area of the brain, which is involved in autonomic nervous functions, emotions, and thermoregulatory mechanisms (Nakamura et al., 2008). It is possible that the tactile stimulation of massage was transmitted to the preoptic area of the brain by information transfer. However, no change due to continuation was observed, as the changes were similar both on the first day and one month after the massage.

On the other hand, there was no difference in axillary temperature in the non-massage group before and after being held both on the first day and one month later. Tabuchi et al. reported that the outside temperature and humidity of the underwear of the newborns being held was higher or the same level as the inside temperature and humidity (Tabuchi et al., 2011), suggesting that being held was only a conduction of heat through contact with the mother and that no heat production was obtained. Therefore, we consider that the axillary temperature of the infants did not change despite being held by their mothers for approximately 15 minutes.

After one month of massage from the mother, the rate of change in the infant's LF/HF ratio during massage decreased significantly; Fuji et al. (2021) reported that heart rate decreased more withheld stimulation than with motorized stimulation. Infants were active during massage, moving their bodies, babbling, and laughing, and were not in a situation where their heart rate decreased. Nomachi et al.(2013) also reported that HF values increased after massage in infants 3-5 months of age. Tactile stimulation by the mother's massage enhanced the infant's parasympathetic function, which in turn stimulated the infant's limb movements, which also enhanced sympathetic function. The parasympathetic function of the infants was enhanced, resulting in suppression of sympathetic function, and only the LF/HF ratio decreased, with no difference in the rate of change in heart rate and HF. TRPM3 is a temperature-sensing receptor in cutaneous

sensory nerves and is also expressed in the brain and other organs, and its activity is enhanced by repeated stimulation (Shirakami, 2008). The increase in the infant's axillary temperature due to tactile stimulation by repeated massage may have contributed to the decrease in the LF/HF ratio after one month.

Based on the above, we believe that tactile stimulation of massage suppressed sympathetic nerve function, but did not lead to predominance of parasympathetic nerve activity. Fuji et al. (2021) reported a decrease in CSI, a measure of sympathetic nerve activity, in 7- and 8-month-old infants held and electrically stimulated in an environment without sound stimulation compared to noise stimulation. Because both groups were at home for the one-month study, the environment was more conducive to the suppression of sympathetic function than on the first day.

On the first day, infants in the two groups were unfamiliar with the facility and the sounds, and only infants in the massage group experienced massage. There was no difference in the rate of change in heart rate, HF, or LF/HF ratio between the two groups.; Aguirre et al. (2019) reported a decrease in heart rate in 9-month-old infants whose caregivers stroked their legs with a brush at a rate of 3 cm/s. Harrison et al. (2020) also reported a decrease in heart rate in infants after massage. Sakaguchi et al. (2006) reported an increase in CV values, an index of parasympathetic nerve function, due to talking from the mother compared to resting newborns at 6 or 7 days of age. In the present study, the results did not agree with these reports.

This is because the mothers also massaged their infants for the first time while listening to the instructor's explanation, and we believe that the pressure and speed of the massage did not reach the point where the parasympathetic nervous activity of the infants became dominant. Fuji et al.(2021) reported a decrease in heart rate in infants stimulated to be held. The children in the non-massage group were held by their mothers for approximately 15 minutes and were often asleep and not spoken to. Despite the fact that the heart rate was easily reduced by being held at rest, no difference was found between the two groups. This suggests that the tactile stimulation of massage suppressed sympathetic nerve function.

2. Assessment of growth and development

Infants who received one month of massage from their mothers showed accelerated development in the expressive language domain, and their overall developmental age exceeded their actual age (in months). Three- and four-month-old infants tend to look favorably at their caregivers (Quinn et al, 2002), and at four months, they are able to distinguish facial expressions of joy, anger, and sadness (Kaneshige et al, 2015; Ahn et al,2023). Ohki et al.(2001) reported that early interventions such as play and massage developed responses to audiovisual stimuli, reflexive behavior, and spontaneous movements in 12-month-olds born at 26 to 31 weeks gestation and weighing less than 1,500 g. The visual acuity of 3- and 6-month-old infants is said to be 0.1 and 0.2, respectively (Yamaguchi et al., 2008). Input information from the retina has a circuit that leads to the amygdala, which is involved in emotion (Koizumi et al., 2010), and visual and auditory information is transmitted to the cerebrum via neurons from each receptor (Iwamura, 2010). Since Matsuda et al. (2017) reported an increase in oxygenated hemoglobin levels during exercise in adult men, the increased blood flow from massage may promote body metabolism and central nervous system activity. The infants were massaged daily for approximately 15 minutes for one month while looking at their mothers' faces and listening to their voices. This is thought to have promoted the infants'

visual and auditory development, as well as their development in the expressive language domain, such as responding to their mother's voice.

Even in the non-massage group, the comprehension language domain developed more than the actual age in months as they grew. We believe that this development was stimulated by stimuli from the surroundings, such as turning the head toward the sound of human voices and looking at us when we called their names, in the same way as in the massage group. The recommended weight gain from 3 to 6 months of age is 15 to 20 g per day (Yokoyama et al.,2012). The infant's weight gain was similar to the recommended weight gain in both groups, indicating that they were growing well. Despite the fact that the massage group had more physical activity, there was no difference between the two groups, massage may have increased metabolic activity.

CONCLUSION

The results of this study indicate that massage by mothers for approximately 15 minutes per day for one month inhibits cardiac sympathetic nerve function and promotes the development of expressive language skills in children. We recommend the mother to naked infant provide tactile stimulation for 15 minutes a day.

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