Relationship between feeding modes and infant weight gain in the first month of life

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Abstract. Breast-feeding and human milk are beneficial for both mothers and their children. This retrospective study aimed to clarify whether differences in feeding mode influence infant weight gain in the first month of life. We analyzed the pregnancy charts of 422 women who delivered at a birthing center in rural Japan between August 1998 and September 2007. The inclusion criteria were low-risk, full-term pregnancy (duration, 37-42 weeks), spontaneous vaginal delivery, and a healthy infant (1 min Apgar score of ≥8) who underwent a health check-up at 1 month postpartum. The subjects were classified into three groups on the basis of feeding modes: exclusive breast-feeding group (28.9%), mixed-feeding group (55.9%) and exclusive formula-feeding group (15.2%). The weight gain/day was 39.7±9.3 g (range, 18.5-67.4 g), 39.5±9.4 g (range, 13.8-64.5 g) and 39.0±9.5 g (range, 14.4-65.3 g) in the exclusive breast-feeding, mixed-feeding and exclusive formula-feeding groups, respectively. Apart from the rate of maternal smoking, which was lower in the exclusive breast-feeding group, no other significant differences were observed among the three groups. This study revealed that there were no differences in weight gain among infants raised exclusively on breast milk and those raised exclusively on formula milk.

Introduction

The American Academy of Pediatrics (1) and the World Health Organization (WHO) (2) recommend exclusive breast-feeding for infants until the age of 6 months. A US national survey conducted in 2001 reported that 33% of infants were breast-fed and 17% were exclusively breast-fed until 6 months of age (3). Breast-feeding is the ideal feeding mode for both infants and mothers. Breast-feeding has beneficial effects in infants and mothers, and it plays a crucial role in public health (1). Human milk is species-specific and contains optimal nutrients, growth factors and the immunological components required for infants (4). Breast-feeding has short-term benefits such as the prevention of infectious diseases in infants, including diarrhea (5-8), respiratory tract infection (9-12) and otitis media (13,14). The long-term health benefits of breast-feeding in infants include a lower risk of developing diseases such as obesity (15,16), hypertension (17,18) and type 1 diabetes mellitus (19,20) in adulthood. Gluckman and Hanson (21) proposed the concept of developmental origins of health and disease, which states that unbalanced nutrition in utero and in infancy leads to subsequent disorders.

Body weight is an important index of infant growth and development. Neonates lose weight because of the physiologic extracellular fluid diuresis following their transition from intrauterine to extrauterine life (22). The normal maximal weight loss is 5.5-6.6% of birth weight in optimally exclusively breast-fed infants and occurs between the second and third day of life (23,24). According to the WHO Multicentre Growth Reference Study, a male infant gains 1,200 g/month and a female infant gains 1,000 g/month under optimal conditions. Weight gain in the first month of life in exclusively breast-fed infants is reported to be 18-35 g (25,26). Although studies indicate sufficient evidence regarding breast-feeding, there is no universal agreement among healthcare providers regarding weight gain in breast-fed and formula-fed infants. When weight gain occurs gradually, appropriate support should be provided after determining whether the infant is demonstrating delayed weight gain or a failure to thrive (27-29).

This retrospective study aimed to clarify whether differences in feeding modes influence neonatal weight gain in the first month of life.

Materials and methods

Study population. This retrospective study involved the review of pregnancy charts of 422 women who delivered at a birthing center in Aomori Prefecture, Japan. The study complied with the principles of the Declaration of Helsinki (Seoul 2008) and the ethical guidelines for epidemiological research issued by the Ministry of Education, Culture, Sports, Science and Technology as well as the Ministry of Health, Labour and Welfare in Japan (2008). All study data were obtained from the medical records of the subjects and were coded to avoid
Table I. Summary and comparison of maternal parameters classified on the basis of feeding modes.

| Parameters                        | Total population | Breast-fed (n=122) | Mixed-fed (n=236) | Formula-fed (n=64) |
|-----------------------------------|------------------|--------------------|------------------|-------------------|
| Age (years)*                      | 26.6±4.5         | 26.8±4.0           | 26.6±4.7         | 26.3±4.9          |
| Duration of pregnancy (weeks)*    | 39.5±1.2         | 39.5±1.1           | 39.6±1.2         | 39.2±1.1          |
| Primiparous*                      | 163 (38.6)       | 44 (36.1)          | 96 (40.7)        | 23 (35.9)         |
| Smokers*                          | 75 (17.8)        | 9 (7.4)            | 48 (20.3)        | 18 (28.1)         |
| Prepregnancy weight (kg)*         | 53.3±8.4         | 52.4±6.8           | 53.7±9.3         | 54.0±7.5          |
| Prepregnancy BMI*                 | 21.2±3.2         | 20.8±2.4           | 21.4±3.5         | 21.4±3.1          |
| Delivery weight                   | 65.2±8.7         | 64.2±7.4           | 65.7±9.2         | 65.3±8.9          |
| Gestational weight gain (kg)*     | 11.8±4.0         | 11.7±3.4           | 12.0±4.3         | 11.3±3.9          |
| Weight at 1 month postpartum (kg)* | 57.9±8.3         | 57.0±7.2           | 58.4±8.9         | 57.6±8.1          |
| Postpartum weight loss (kg)*      | 7.3±2.3          | 7.2±2.1            | 7.3±2.3          | 7.7±2.6           |

Values are presented as means ± SD. BMI, body mass index (weight in kilograms divided by the square of the height in meters (kg/m²)); *One-way analysis of variance, a P<0.05. a Presented as number and percent and analyzed with the \( \chi^2 \), a P<0.01.

disclosure of the their identity. We gathered the medical records of 579 women who had a singleton pregnancy and delivered a live infant from August 1998 to September 2007. The inclusion criteria were low-risk, full-term pregnancy (duration, 37-42 weeks), spontaneous vaginal delivery, <500 ml intrapartum blood loss and a healthy infant (1 min Apgar score of ≥8) who underwent a health check-up at 1 month postpartum. Mothers with chronic diseases (e.g., diabetes, hypertension and hyperthyroidism), gestational diabetes, and pregnancy-induced hypertension were excluded from the study. Records with unknown or missing obstetric data were not included. A total of 422 records were finally available for analysis.

Perinatal parameters. The perinatal parameters extracted from the pregnancy charts were maternal age, parity, smoking status, self-reported prepregnancy weight, prepregnancy body mass index (BMI), gestational weight gain, chronic diseases, delivery mode, duration of pregnancy, infant gender, infant size at birth (weight, height, head circumference and chest circumference), 1 min Apgar score, admission to hospital, and data from the first month health check-up (mother’s weight, feeding mode and infant size).

Feeding modes. Subjects were divided into three groups on the basis of self-reported feeding mode used by mothers in the first postpartum month: an exclusive breast-feeding group, a mixed-feeding (breast-feeding and formula-feeding) group, and an exclusive formula-feeding group.

Statistical analysis. Statistical analysis was performed using SPSS software, version 16.0 (SPSS Japan, Inc., Tokyo, Japan) for Windows. Descriptive statistics are indicated as arithmetic mean ± standard deviation. A two-sample t-test, one-way analysis of variance, and Tukey’s honestly significant difference test were performed to determine differences across the three groups. The \( \chi^2 \) statistic was used to analyze categorical variables. Univariate analysis was performed using Pearson’s correlation coefficient. A P-value of <0.05 was determined to be indicative of a statistically significant result.

Results

Summary of the study population. The maternal parameters of the study population are summarized in Table I. The mean maternal age was 26.6±4.5 years (range, 17-38 years); 38.6% subjects were primiparas and 17.8% were smokers. The mean duration of pregnancy was 39.5±1.2 weeks. The infant parameters of the study population are summarized in Table II. The mean infant birth weight and height were 3,209±370.4 g and 54.9±1.6 cm, respectively; 49.8% infants were male. The mean infant weight and height at 1 month were 4,513.2±451 g and 67.4±1.8 cm, respectively; 49.8% infants were male. The mean infant weight and height at 1 month were 4,513.2±451 g and 67.4±1.8 cm, respectively; 49.8% infants were male.

The study population was classified into the following three groups on the basis of the feeding mode: breast-feeding (28.9%), mixed-feeding (55.9%) and formula-feeding (15.2%) groups. The overall maternal smoking rate was 17.8%, the smoking rates for the exclusive breast-feeding, mixed feeding, and exclusive formula-feeding groups were 7.4, 20.3 and 28.1%, respectively. The smoking rate was significantly lower in the exclusive breast-feeding group than in the other groups. Except for maternal smoking status, none of the other maternal and infant parameters significantly differed among the three feeding modes.

Relationship between weight gain and maternal/neonatal parameters. Infant weight gain/day in the first month of life was determined for feeding modes, parity and infant gender (Fig. 1). The daily weight gain was 39.7±9.3 g (range, 18.5- 67.4 g) in the exclusive breast-feeding group, 39.5±9.4 g (range, 13.8-64.5 g) in the mixed-feeding group, and 39.0±9.5 g (range, 14.4-65.3 g) in the exclusive formula-feeding group.
No significant differences in daily weight gain were observed among the feeding modes (Fig. 1A). The daily infant weight gain was significantly higher in the male infants (42.1±9.3 g) than in the female infants (36.9±8.8 g) (Fig. 1B), but did not differ between primiparous and multiparous mothers (Fig. 1C).

Multiple linear regression analysis was used to identify independent variables associated with infant weight gain (Table III). Although the coefficient of determination ($R^2$) was low, infant gender, birth weight, birth height, and maternal age were identified as variables that could independently predict the weight gain/day in the first month of life ($R^2=0.13, P<0.001$ by ANOVA).
Discussion

In Japan, breast-feeding has been promoted since 1989 according to a joint announcement “The Ten Steps to Successful Breastfeeding” released by WHO/UNICEF. According to a national Japanese study in 2005, 42.4% infants aged 1 month, 38.0% aged 3 months, and 34.7% aged 6 months were exclusively breast-fed (30). However, in our retrospective study, 28.9% infants were exclusively breast-fed at 1 month after birth, indicating that the values in our study in Japan were below the national average. The results obtained in the present study were possibly affected by regional characteristics, different attitudes, and/or lack of education on breast-feeding. Moreover, relatively higher birth weights of both male (3,235 g) and female (3,183 g) infants were observed in our study when compared with the average birth weight in Japan (male infants, 3,040 g; female infants, 2,960 g) (31). This finding may be attributed to the low-risk pregnancies, young maternal age, and high rate of multiparity and full-term deliveries in our study. Except for the rate of maternal smoking, which was lower in the exclusive breast-feeding group than in other groups, none of the other maternal and infant parameters assessed in this study significantly differed among the three groups.

According to the WHO Multicenter Growth Reference Study, a male infant gains 1,200 g/month and a female infant gains 1,000 g/month under optimal conditions (25). In the current study, the male infants gained 1,391.1±328.4 g/month (42 g/day) and the female infants gained 1,216.7±297.7 g/month (36.9 g/day). WHO (32) and Dewey (33) reported that male infants gain significantly more weight than female infants. Breast-fed infants weighed significantly less than formula-fed infants at ages 3 months to 2 years; however, no significant differences in weight were observed at age 2-3 months (34-36). The weight gained in the first month after birth did not differ with the feeding modes; this finding was consistent with that of a previous study (24). Exclusively breast-fed infants may gradually gain weight in the first month of life. However, delayed weight gain cannot be disregarded as it may be associated with less than optimal breast-feeding or illness in the infant (e.g., congenital heart disease, neuromuscular disease, infection, or endocrine and metabolic abnormalities). Therefore, infant weight gain assessments must take into account potential illnesses in addition to maternal health, the condition of breast milk, and infant position and latching during breast-feeding. Furthermore, some infants gain less than 20 g/day regardless of the feeding mode. Factors affecting the mother's and infant's health after childbirth include abuse, parenting anxiety, and postpartum depression; therefore, the mother's physical and mental state should be assessed along with the infant's condition. Continuous support provided to the mother and infant soon after discharge from the hospital is related with improved health of both the mother and her infant.

The present study revealed that weight gain in the first month of life does not significantly differ between exclusively breast-fed infants and exclusively formula-fed infants (Fig. 1). Poor weight gain in infants is not only caused by poor milk intake due to incorrect suckling or insufficient lactation but may also be associated with illness in the infant. Breast-feeding improves the health and development of both the mother and infant. Therefore, assessment of feeding soon after birth is crucial with regard to infant growth and development and prevention of diseases in adulthood. Healthcare providers working with mothers and infants should understand the patterns of growth and development of exclusively breast-fed infants, correctly assess the effectiveness of breast-feeding, and provide continuous support so that both the mother and infant benefit from breast-feeding.

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