

Short- and Long-Term Decrease of Blood Pressure in Women During Breastfeeding

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Abstract

Background and aims: The benefits of breastfeeding for infants are well known. Recently data have started to emerge showing that breastfeeding may also induce positive effects in the mother. This study aimed to investigate the pattern of maternal blood pressure before, during, and after a breastfeed 2 days postpartum. Additionally, blood pressure during the following 25-week breastfeeding period was investigated.

Methods: Sixty-six primiparae with normal deliveries were consecutively recruited. Blood pressure was measured at -5, 10, 30, and 60 minutes in connection with a morning breastfeed. Thirty-three women continued to measure blood pressure before and after breastfeeding for 25 weeks.

Results: Blood pressure fell significantly in response to breastfeeding 2 days after birth. The fall in systolic and diastolic blood pressure amounted to 8.8 (SD = 11.00) and 7.7 (SD = 9.3) mm Hg, respectively. During the 25-week follow-up period a significant fall of basal blood pressure (systolic, $df = 3$, $F = 7.843$, $p < 0.001$; diastolic, $df = 3$, $F = 5.453$, $p = 0.002$) was observed. The total fall in systolic and diastolic blood pressure amounted to a mean of 15 (SD = 10.4) mm Hg and 10 (SD = 9.7) mm Hg, respectively. In addition, blood pressure fell significantly in response to individual breastfeeding sessions during the entire observation period.

Conclusions: In conclusion, both systolic and diastolic blood pressures fall during a breastfeeding session, and pre-breastfeeding blood pressure decreases during at least the first 6 months of a breastfeeding period in a homelike environment. This study lends further support to the health-promoting effects of breastfeeding.

Introduction

THE BENEFITS OF BREASTFEEDING for infants are well known. Recently data have started to emerge showing that breastfeeding may also induce positive effects in the mother. The observed effects range from adaptations helping the mother attach to and care for her children¹⁻³ to behavioral and physiological changes in the mother. Personality changes also occur, expressing increased levels of socialization and calm.^{4,5} Furthermore, maternal reactions to certain kinds of stress are blunted.⁷ The physiological changes include an immediate decrease of blood pressure and cortisol levels in response to each individual breastfeeding session, as well as a rise of the levels of vagally controlled gastrointestinal hormones.^{6,8,9} In a more long-term perspective, maternal cortisol levels in response to physical stress are reduced.¹⁰

Oxytocin, which is produced in the supraoptic and paraventricular nuclei of the hypothalamus, was originally known to stimulate uterine contractions during labor and

milk ejection during breastfeeding.¹¹ Oxytocin has, however, been shown to have a much broader pattern of effects. It has been demonstrated to facilitate bonding between mother and young and to induce maternal behavior in several types of mammalian species.¹² Repeated administration of oxytocin has also been found to induce calm and long-term anti-stress effects, such as lowering of blood pressure and corticosterone levels in rats of both sexes.¹³⁻¹⁵

Since oxytocin is released in response to suckling, it is possible that some of the behavioral and physiological adaptations observed in breastfeeding women are caused by oxytocin. Data showing that psychological adaptations associated with increased levels of socialization and calm are related to the levels and/or the release pattern of oxytocin induced by breastfeeding support this hypothesis.^{5,16} Furthermore, data showing that mothers with high oxytocin levels have lower blood pressure demonstrate an association between oxytocin and low blood pressure.¹⁷

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It is not known, however, when blood pressure decreases during a breastfeeding session or for how long a time it lasts. Furthermore, it is not known whether blood pressure continues to decrease in response to a breastfeeding session during the entire lactation period and/or whether a sustained lowering of basal blood pressure occurs.

Some studies suggest that breastfeeding may influence blood pressure in a more long-term perspective,^{18,19} and postpartum non-lactating women were shown to have higher systolic blood pressure than lactating women.²⁰ Multiparae have lower blood pressure than primiparae during pregnancy, suggesting that blood pressure was decreased by the previous pregnancy and/or breastfeeding.¹⁹ Recently, it has been demonstrated that lactation diminishes the risk for development of hypertension in women later on in life, further supporting the notion that breastfeeding may induce long-term positive effects on blood pressure.¹⁸

The aim of this study was twofold: (1) to make a detailed characterization according to size and duration of the pattern of maternal blood pressure in response to a breastfeeding 2 days after birth and (2) to study the breastfeeding-related changes in blood pressure in a more long-term perspective by recording blood pressure before and after breastfeeding during a 25-week follow-up period.

Subjects and Methods

Inclusion criteria

The study was conducted at one of the six maternity clinics in Stockholm, Sweden, during January 2002 to December 2003. The following strict criteria had to be fulfilled in order to be included in the study: the mothers should be primiparous, be non-smokers, and have a body mass index less than 30 kg/m², the mothers should have had no signs of hypertension during pregnancy or birth, the delivery should have been normal without any complications for mother or infant, the infant should have an Apgar score of at least 8 at 1 minute after birth, the mother and her infant should not have been separated after birth (not even for medical examinations), and the infant should have been exclusively breastfed and not been given any formula. All mothers satisfying these criteria, who were admitted to the maternity ward on weekdays (Monday–Friday), were consecutively informed 10–24 hours after delivery about the study by the two midwives conducting all the experiments. In total, 86 mothers were informed about participation; of those, 20 mothers declined participation.

Ethical consent

The ethics committee at the Karolinska Institutet, Stockholm, Sweden, approved the study.

Eligible non-participants

There were no significant differences in maternal age, duration of pregnancy, duration of 1st and 2nd stage of labor, or neonatal birth weight between the participating mothers and the mothers who had declined study participation. However, of the 20 mothers who had declined participation, 13 had received an epidural analgesia, and three had received oxytocin intravenously, whereas four had received no medical intervention at all.

Procedures during the breastfeeding experiment 2 days after birth

The experiments were performed on day 2 after birth, when the babies were 24–48 hours old, in the mothers' own room at the maternity ward. Thus, the mothers were not moved to another room for the purpose of the experiment. At the clinic where the study was conducted, day and night rooming-in is practiced. The rooms are designed to create a friendly and home-like atmosphere. The fathers or partners are present during birth and during the subsequent days at the maternity ward. Frequent breastfeedings as well as skin-to-skin contact between parents and newborns are encouraged.

The mothers were told to rest in the supine position for 10 minutes before the experiment and were asked to call for the researchers in the morning when the newborns showed signs of rooting behavior. The newborns were in the bed of their mothers and were then placed in the breastfeeding position, i.e., in skin-to-skin contact on the mother's chest. The infants' legs and trunk were covered with a light blanket in order to keep them warm. The mothers were told to behave openly, at their own inclination, and that the researchers would not interfere. Also, the mothers could ask the researchers to assist their breastfeeding, if needed. Conversation was minimized during the observation period.

The infants initiated breastfeeding themselves. The mothers were asked to stay in the breastfeeding position for 60 minutes, irrespective of active breastfeeding.

Determination of blood pressure during breastfeeding 2 days after birth

Maternal blood pressure was measured by means of a blood pressure monitor (Omron R5-1 Wrist blood pressure monitor, Omron Healthcare, Hoofddorp, The Netherlands), which was attached to the mother's right wrist. Blood pressure was measured at 5 minutes before the infants were placed in skin-to-skin contact with their mothers and at 10, 30, and 60 minutes after breastfeeding had been initiated.

Procedures during the follow-up study

Thirty-three mothers participated in the follow-up study that proceeded for 25 weeks. Since data for some time points were lacking in some individuals, the number of participants included in the statistical calculations varied (see Table 3). However, there were no significant differences regarding maternal age, duration of pregnancy, duration of 1st and 2nd stage of labor, neonatal birth weight, and blood pressure values between the mothers participating in the entire follow-up study and the mothers who had dropped out.

The mothers received a blood pressure monitor of the same type described above along with instructions on how to attach it to their right wrist and to measure blood pressure by themselves. The mothers were told to rest for 10 minutes before they breastfed in the morning and to measure blood pressure both before and after breastfeeding while in the supine position.

The breastfeeding mothers were contacted by the research team via telephone every third week. They were then asked about the blood pressure measurements and the progress of breastfeeding to ensure that all infants were exclusively

TABLE 1. CLINICAL AND BREASTFEEDING DATA OF MOTHERS AND THEIR NEWBORNS

	All mothers (n = 66)
Age (years)	30.2 (3.5)
Duration of pregnancy (weeks)	39.7 (1.1)
Duration of 1 st + 2 nd stage of labor (hours:minutes)	10:20 (4:56)
Interventions received in connection with childbirth (number of mothers)	
Oxytocin infusion	21
Epidural analgesia	21
Oxytocin injection (10 IU postpartum)	15
Acupuncture	17
Neonatal weight (g)	3,606 (435)
Neonatal age at experiment (hours)	34.21 (8.3)
Number of breastfeedings since birth in	
All newborns	7.1 (3.2)
Newborns ≤36 hours	5.58 (2.47)
Newborns >36 hours	9.52 (2.97)
Duration of skin-to-skin contact before breastfeeding (minutes:seconds)	5:19 (6:24)
Duration of breastfeeding (minutes)	26.9 (13.5)

Data are mean (SD) values.

breastfed during the entire follow-up period. None of the mothers had returned to work during the study period.

Data analysis

Data were analyzed using the SPSS program (Statistical Package for the Social Sciences®, Chicago, IL) version 14.0. The mean and standard deviation (SD) values were used to describe background and blood pressure data. Because of missing values, the number of mothers differed between the different calculations.

Analyses of variance for repeated measurements with contrasts were used to analyze the development of blood pressure over time in the breastfeeding experiment performed 2 days after birth ($n = 63$) and in the follow-up study ($n = 19$). For calculating differences in blood pressure before and after each breastfeeding session in the follow-up study ($n = 23$ – 33), paired t tests were used.

Results

Clinical background data

Background data on mothers, newborns, and breastfeeding are given in Table 1.

Blood pressure during the breastfeeding experiment on day 2 after birth

Blood pressure was recorded at 5 minutes before skin-to-skin contact and at 10, 30, and 60 minutes after onset of breastfeeding. The mean systolic and diastolic blood pressure amounted to 125.8 (SD = 11.75) mm Hg and 80.7 (SD = 9.8) mm Hg, respectively, at the start of the experiments, i.e., 5 minutes before skin-to-skin contact (Fig. 1 and Table 2). Analysis showed that there was a significant fall in systolic and diastolic blood pressure over time ($df = 3$; $F = 19.929$, $p < 0.001$ and $F = 16.727$, $p < 0.001$, respectively). The total fall in systolic and diastolic blood pressure during the entire experiment amounted to 8.8 (SD = 11.0) and 7.7 (SD = 9.3) mm Hg, respectively. In addition, both systolic and diastolic

blood pressure fell significantly between each observation during the breastfeeding experiment on Day 2. There was a significant fall in both systolic ($df = 1$, $F = 5.772$, $p = 0.020$) and diastolic ($df = 1$, $F = 8.005$, $p = 0.006$) blood pressure already after 10 minutes of breastfeeding (Table 2).

Long-term effects of breastfeeding on blood pressure

Thirty-three mothers continued to measure blood pressure before and after breastfeeding at home for 25 weeks. These mothers reported that they were exclusively breastfeeding. Nineteen mothers had a complete series of blood pressure measurements. There were no significant differences regarding maternal age, duration of pregnancy, duration of 1st

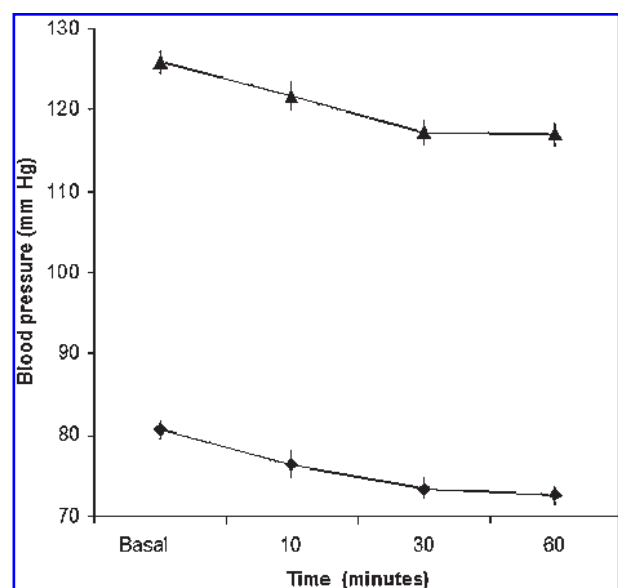


FIG. 1. Blood pressure recorded at 5 minutes before skin-to-skin contact (basal) and at 10, 30, and 60 minutes after onset of breastfeeding: systolic (▲) and diastolic (◆).

TABLE 2. SYSTOLIC BLOOD PRESSURE (SBP) AND DIASTOLIC BLOOD PRESSURE (DBP) DURING A BREASTFEED 2 DAYS POSTPARTUM

Blood pressure at	Mean (SD)	
	SBP	DBP
Basal	125.8 (11.8)	80.7 (9.8)
10 minutes	121.8 (14.7)	76.4 (13.9)
30 minutes	117.2 (12.7)	73.4 (11.2)
60 minutes	117.0 (12.6)	72.6 (10.4)

Blood pressure data (in mm Hg) are mean (SD) values.

and 2nd stage of labor, and neonatal birth weight between the 66 mothers participating in the experiment on Day 2, and the 33 mothers asked to participate in the follow-up study.

The systolic and diastolic blood pressures obtained before breastfeeding 2 days after birth and at 1, 10, and 25 weeks after birth were included in the analysis, which showed that mothers' blood pressure exhibited a fall during the entire observation period. The decrease was significant for systolic ($df = 3$, $F = 7.843$, $p < 0.001$) and diastolic ($df = 3$, $F = 5.453$, $p = 0.002$) blood pressures and amounted to a mean of 15 (SD = 10.4) mm Hg and 10 (SD = 9.7) mm Hg, respectively (Fig. 2). In addition, a significant fall in systolic and diastolic blood pressure was observed between weeks 1 and 10 ($p = 0.003$ and $p = 0.022$, respectively) and between weeks 10 and 25 ($p = 0.04$ and $p = 0.020$, respectively).

Furthermore, blood pressure continued to fall significantly during most breastfeeding sessions during the 25-week follow-up (Table 3).

Discussion

The main findings in this study were that both systolic and diastolic blood pressure fell significantly in connection with a breastfeeding experiment 2 days after birth and that a continuous and significant fall of pre-breastfeeding systolic and diastolic blood pressure was observed over a long-term follow-up study including women breastfeeding for 6 months. In addition, blood pressure continued to fall significantly in response to most of the breastfeeding sessions during the 6-month study period.

The present data showing a decrease in blood pressure in response to a breastfeeding session are in agreement with those previously presented by Nissen et al.⁶ and Light et al.¹⁷ In our study, the fall in blood pressure was described in more detail. It was found to decrease 8.8 and 7.7 mm Hg (systolic and diastolic blood pressure, respectively), to begin to fall already within the first 10 minutes of breastfeeding, and to last for at least 60 minutes.

It might be argued that the decrease in blood pressure during breastfeeding is related to the close interaction between mother and infant and not the suckling stimulus per se. A study where breastfeeding women and women feeding their infants artificial breast milk would be compared would be impossible to perform in the Swedish setting since in Sweden, breastfeeding is the standard rather than the exception. For instance, 98% of women breastfeed in the first week post-

partum. Therefore we have to rely on data obtained by other investigators. In a study conducted by Light et al.¹⁷ it was shown that breastfeeders had a significant decrease systolic and diastolic blood pressure for 1 hour during and after baby feeding; bottlefeeders did not exhibit this fall. In addition, in a study performed by Altemus et al.¹⁰ breastfeeding mothers exhibit lower systolic blood pressure after a stress test, whereas bottlefeeders did not. Together these studies support the proposal that it is the suckling stimulus that influences the decrease in blood pressure.

The fall in blood pressure may be caused by the release of oxytocin occurring in response to breastfeeding. Oxytocin is produced in the supraoptic and paraventricular nuclei in the hypothalamus and is released into the circulation via the neurohypophysis to activate receptors in the myoepithelial cells to cause milk ejection.¹¹ In addition, oxytocinergic nerves project from the paraventricular nucleus to important regulatory centers in the brain, among those the autonomic centers in the brainstem important for control of cardiovascular function, such as the nucleus tractus solitarius and the dorsal vagal motor complex.¹² The suggestion that oxytocin contributes to the lowering of blood pressure observed in response to the suckling stimulus is supported by animal experiments in which administration of oxytocin has been shown to decrease blood pressure.¹³

As described above, the infants were placed skin-to-skin with their mothers before they started to breastfeed. While lying in skin-to-skin contact on their mothers' chest, the infants stimulate maternal oxytocin release by massage-like movement with their hands, as demonstrated in previous work by our group examining the infant's role in postpartum oxytocin release.²¹ Such movements may via oxytocin release have contributed to the decrease in blood pressure observed during the present experiment.

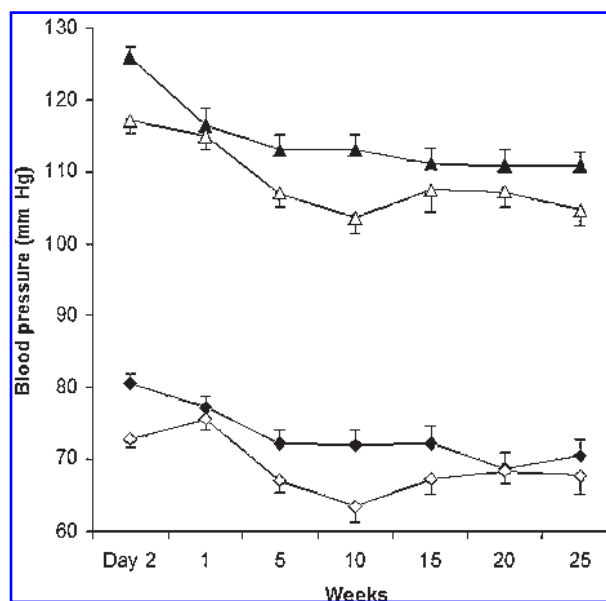


FIG. 2. Systolic (top) and diastolic (bottom) blood pressures obtained before (solid symbols) and after (open symbols) breastfeeding 2 days after birth and at 1, 5, 10, 15, 20, and 25 weeks after birth.

TABLE 3. SYSTOLIC BLOOD PRESSURE (SBP) AND DIASTOLIC BLOOD PRESSURE (DBP) BEFORE AND AFTER BREASTFEEDING AND THE MEAN DECREASE BETWEEN THESE TWO INTERVALS DURING THE 6-MONTH FOLLOW-UP PERIOD

		Blood pressure relative to breastfeeding				
Blood pressure, breastfeeding at	n	Before	After	Decrease	t	p value
SBP						
Day 2	63	125.9 (11.8)	117.1 (12.8)	8.8 (11.0)	6.377	<0.001
1 week	33	116.5 (13.4)	114.9 (10.1)	1.6 (12.3)	0.763	0.451
5 weeks	28	113.0 (11.2)	107.1 (10.4)	5.9 (10.7)	2.925	0.007
10 weeks	27	113.0 (11.5)	103.7 (12.0)	9.4 (10.8)	4.519	<0.001
15 weeks	23	111.1 (10.1)	107.4 (13.9)	3.7 (8.8)	2.034	0.054
20 weeks	25	110.9 (11.3)	107.2 (10.3)	3.7 (8.7)	2.131	0.044
25 weeks	23	110.9 (9.7)	104.6 (9.7)	6.3 (8.3)	3.629	0.001
DBP						
Day 2	63	80.7 (9.9)	72.9 (10.3)	7.7 (9.3)	6.626	<0.001
1 week	33	77.1 (8.6)	75.7 (9.1)	1.4 (10.2)	0.803	0.428
5 weeks	28	72.3 (9.5)	67.1 (8.8)	5.3 (9.3)	3.00	0.006
10 weeks	27	72.0 (10.6)	63.4 (10.6)	8.6 (12.6)	3.548	0.002
15 weeks	23	72.3 (10.9)	67.3 (10.6)	4.9 (10.1)	2.352	0.028
20 weeks	25	68.8 (10.1)	68.4 (8.7)	0.4 (12.2)	0.164	0.871
25 weeks	23	70.6 (11.2)	67.8 (12.3)	2.8 (10.3)	1.293	0.209

Data are mean (SD) values, degrees of freedom (*df*), and *t* and *p* values.

Our data demonstrating a fall of blood pressure in response to breastfeeding are seemingly in contrast to those presented by Mezzacappa et al.²² in which blood pressure was found to rise significantly during breastfeeding; bottlefeeders did not exhibit this rise. Also, the rise of blood pressure may be a consequence of oxytocin release, since the effect spectrum of oxytocin is complex. In fact, a short-term increase of blood pressure has been observed in response to oxytocin administration in some experimental models,²³ in particular in response to an unexpected stressor.²⁴ The differences observed between our study and the one by Mezzacappa et al.²² may be related to different experimental conditions. Our study was performed in a calm and home-like setting by midwives who were previously known to the mothers, whereas the study by Mezzacappa et al.²² was performed in a conventional laboratory environment, unfamiliar to the mothers. Thus, the experimental setting may be of importance for the type of effect triggered by oxytocin in breastfeeding mothers. Provided the mothers are breastfeeding in a well-known environment an oxytocin-related decrease in blood pressure may be induced, whereas an increase in blood pressure may be triggered when women breastfeed in an unfamiliar environment. It must therefore be assumed that the breastfeeding mother has the capacity to "judge" whether the surrounding could be regarded as safe and pleasant or as dangerous and unpleasant. This unconscious interpretation of the environmental circumstances involves the amygdala hippocampal complex and leads to either a defense reaction or a calming response.^{25,26}

A further difference between the studies, as discussed above, was that the mothers in our study were allowed a period of skin-to-skin contact before the infant him- or herself initiated breastfeeding. This period of skin-to-skin contact before breastfeeding may serve to facilitate the relaxing ef-

fects of oxytocin. Thus, pleasant sensory stimulation may, by analogy, be exerted by a pleasant and safe environment and promote the effect of oxytocin to induce calm and relaxation.^{25,27}

An important finding was that basal blood pressure showed a continuous fall during the entire breastfeeding period. Thus, the pre-breastfeeding mean systolic blood pressure decreased around 15 mm Hg, and the mean diastolic blood pressure around 10 mm Hg during the 6-month study period. Also, the prolonged effect of breastfeeding can be attributed to effects of oxytocin. Interestingly, animal data show that the effect on blood pressure becomes stronger and sustained after repeated exposure to oxytocin. In female rats, blood pressure is significantly decreased for 3 weeks after the last of five injections of oxytocin.¹³ This change has been linked to an increased function of α_2 -adrenoceptors, which act by inhibiting the effect in central (nor)adrenergic signaling systems involved in the control of blood pressure.^{13,28} Thus, the activity is enhanced in the noradrenergic neurons emanating from the locus coeruleus, as well as in the brainstem areas, such as the nucleus tractus solitarius, linked to regulation of blood pressure. Similar adaptive changes in the function of signaling systems may lie behind the progressive and long-term lowering of blood pressure observed in breastfeeding women during the follow-up study.

The long-term fall in blood pressure may be part of a psychophysiological adaptation to breastfeeding in an anti-stress direction. This finding is in line with previous reports by Domes et al.,⁷ Light et al.,¹⁷ and Altemus et al.¹⁰ Such a general anti-stress effect of oxytocin may explain why breastfeeding women have demonstrated as being less sensitive to several types of mental stressors,⁷ why they release less cortisol in response to physical exercise,¹⁰ and, furthermore,

why the women display changes of their personality profile as measured by the Karolinska Scales of Personality towards calm and relaxation.^{5,16}

The long-term anti-stress effect induced by breastfeeding needs further consideration. In fact, these effects may remain long after breastfeeding has ceased serving as a buffering mechanism to stress in women. The present findings are in line with previous data showing that multiparae have lower blood pressure throughout pregnancy than primiparae, suggesting that the regulatory mechanisms by which blood pressure is controlled have been sensitized by previous exposure to pregnancy and breastfeeding.¹⁹ Also, recent studies show that women who have breastfed have a reduced risk of developing hypertension¹⁸ and diabetes type II,²⁹ suggesting cardiovascular protective effects. These preventive effects are even related to the duration of breastfeeding. Since oxytocin is released by breastfeeding these anti-stress effects may be caused by repeated exposure to oxytocin.^{15,30} Studies are in progress to further elucidate and identify the mechanisms behind these effects.

In conclusion, both systolic and diastolic blood pressure fall during a breastfeeding session, and pre-breastfeeding blood pressure decreases during at least the first 6 months of a breastfeeding period in a home(-like) environment. This study lends further support to the health-promoting effects of breastfeeding.

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