New Insight into Onset of Lactation: Mediating the Negative Effect of Multiple Perinatal Biopsychosocial Stress on Breastfeeding Duration

Peng Zhu,¹ Jiahu Hao,² Xiaomin Jiang,³ Kun Huang,² and Fangbiao Tao¹

Abstract

Background: Many perinatal stressors, including high prepregnancy body mass index, preterm birth, and cesarean section, increase the risk for short breastfeeding duration. Few studies, however, have investigated the mechanism in the relationship between perinatal determinants and breastfeeding duration. This study aimed to test the hypothesis that delayed onset of lactation (OL) could mediate the negative effect of perinatal biopsychosocial stress on breastfeeding duration and to evaluate the impact of new perinatal factors with potentially hazardous effects.

Subjects and Methods: Maternal demographic characteristics, health status, and psychological stress during pregnancy were assessed by structured questionnaires and medical records. The information of lactation was collected in the hospital within 1–3 days after delivery. Data on breastfeeding behaviors were obtained through the telephone interview at 2 months after delivery.

Results: The risk of delayed OL increased in women who had experienced severe life event stress in the first trimester of pregnancy (adjusted risk ratio [RR] 2.59, 95% confidence interval [CI] 1.52, 4.40), had undergone cesarean section (adjusted RR 2.11, 95% CI 1.46, 3.05), whose gestational body mass index gain were not less than 7.62 (adjusted RR 1.90, 95% CI 1.27, 2.86), and whose breastfeeding frequency was less than three times in the first day after childbirth (adjusted RR 2.14, 95% CI 1.57, 2.91). The final model of structural equation modeling indicated that women with cesarean section, preterm birth, greater gestational body mass index gain, higher scores of stressful life events in the first trimester, and less breastfeeding frequency in the first day after delivery were more likely to experience delayed OL, which could result in an earlier breastfeeding termination.

Conclusions: Delayed OL, as a negative biological event resulted from the perinatal biopsychosocial stress, is a key mediator linking perinatal factors to breastfeeding duration. More attention should to be paid to underweight before pregnancy and severe life events during pregnancy, which are regarded as novel and remarkable risk factors of delayed OL and short breastfeeding duration.

Introduction

IT IS RECOMMENDED by the World Health Organization that exclusive breastfeeding be for 6 months and that breastfeeding should continue for up to 2 years and beyond after delivery.^{1–3} The data from 2000–2009, however, indicated that the rate of breastfeeding in urban areas of China remained below the national targets, with only about half mothers exclusively breastfeeding their infants.^{4,5}

A wide range of sociocultural and physiological factors could potentially impact on breastfeeding behaviors of a woman and her ability to breastfeed successfully. Several

previous studies have suggested that perinatal factors,^{6–8} such as preterm birth, cesarean section, maternal socioeconomic status, and stress during labor,^{9–11} may be associated with increased risk of early termination of breastfeeding, but the mechanism in the relation between perinatal determinants and breastfeeding duration still waits to be unveiled.

Availability of breastfeeding is based on the appropriate onset and effective maintenance of lactation postpartum, and the negative effect of delayed onset of lactation (OL) on breastfeeding duration has been confirmed in human studies.^{12,13} Delayed OL is frequently blamed on stress, such as those imposed by greater body mass index (BMI) during

¹Department of Maternal and Child Health, Anhui Medical University, Hefei, China.

²Anhui Provincial Key Laboratory of Population Health & Aristogenics, Anhui Medical University, Hefei, China.

³Department of Gynecology and Obstetrics, Hefei Maternal and Child Health Hospital, Hefei, China.

pregnancy, cesarean section, and stress during pregnancy and delivery.^{14,15} The biological mechanism was reported to be contributed to by the responsive release of prolactin and oxytocin when stress is experienced.^{16–19} These data suggested that perinatal biopsychosocial stress might suppress the initiation and maintenance of lactation and thus subsequently result in an early breastfeeding termination. It is a pity that few studies have provided direct evidence addressing this hypothesis. In contrast, some researchers from developed countries have argued that underweight before pregnancy may not increase the risk of earlier breastfeeding cessation.^{20–22} However, there is little evidence from developing countries, where many women are underweight before pregnancy.

In the present study, with a prospective study design, we aimed to test the hypothesis that OL could mediate the negative effect of multiple perinatal biopsychosocial stress on breastfeeding duration in primiparous woman who planned to breastfeed for at least 2 months after delivery. Also, we expected to evaluate the impact of new perinatal factors with potentially hazardous effects, especially severe life events during different stages of gestation and lower prepregnancy BMI, on delayed OL and the early termination of any breastfeeding.

Subjects and Methods

Subjects

This study was nested in a prospective cohort study of pregnant women from the China-Anhui Birth Cohort Study, a longitudinal cohort study designed to investigate the association between maternal biopsychosocial risk factors and child development.

In total, 3,316 married pregnant women who gave birth between March to November 2008 in Hefei Maternal and Child Health Hospital (Hefei, China) were invited to participate, and 2,552 pregnant women in the third trimester of pregnancy participated in the project after giving informed consent. In this study, exclusion criteria included delivery before 32 weeks of gestation ($n=14$), unwilling to breastfeed for at least 2 months ($n=39$), pregnancy with assisted reproductive technology ($n=6$), multiparas ($n=134$), superfetation ($n=48$), complications with pregnancy including diabetes mellitus, hypertension, glandula thyroidea disease, and intrahepatic cholestasis of pregnancy ($n=263$), history of abnormal pregnant outcome including fetal death, stillbirth, birth defect, and neonatal death ($n=43$), stillbirth ($n=11$), and birth defect ($n=12$). Of the original 2,552 pregnant women recruited during the third trimester, 2,017 were eligible. Two months postpartum, another 415 participants with incomplete information were further excluded, of whom 266 were lost to follow-up and 149 could not provide information. Finally, 1,602 women were visited, and data on breastfeeding were collected by telephone interviews at 2 months postpartum.

The study was approved by the Ethical Committee of Anhui Medical University (Hefei), and informed consent was obtained from the participants.

Prenatal data

Initial interviews were conducted to assess maternal socioeconomic characteristics, such as maternal age, income,

educational attainment, and psychosocial factors, including social support and stressful life events. The income level was categorized as self-perceived status (lower, medium, or higher). Educational attainment was described as educational years and classified into no more than 9 years and more than 9 years. Social support was defined as that one had availability of assistance if needed or had received actual received assistance, which included companionship or emotional, tangible, informational support. It was assessed using the Chinese Revised Edition of the Social Support Scale.²³ This scale included including 10 items with the total score ranging from 12 to 64. The higher the score was, the more psychosocial resources people would have. Division into quartiles was used, and four grades were categorized as lower support, medium-low support, medium-high support, and high support.

Participants were required to complete a 19-item inventory of stressful life events²⁴ for assessing the occurrence of specific events during the first trimester (0–12 weeks), second trimester (13–24 weeks), and third trimester (25–36 weeks), respectively. All the 19 items were classified into four domains: financial domain (four items: husband lost job, subject herself lost job, fortune loss, and be robbed or cheated), emotion (six items: moved to new address, live apart, housing stress, fright, family member gambling, and spouse went to jail), traumatic events (five items: husband ill, husband died, subject herself ill, family member ill, and family member died), and spousal related (four items: divorce, argument with partner, in-fight, and poor marital relation). Two blank items were added into the checklist in case of any missing stressful life events that might be excluded from the 19 items mentioned above. Participants were asked to indicate whether the event had occurred during pregnancy, using a dichotomous (yes/no) response scale. If the event occurred, they were asked to recall when it occurred by which the gestational age was determined and to weight their perception of its impact on their lives, from no impact (0) to extreme impact (4). The sum of the rating score in each event was used to assess women's perception on stress during the first, second, and third trimesters. We also assumed that the effects of stressful life events were cumulative and additive across the various events. Total value of the four domains with 0, 1, and 2 or greater was defined as no stress, modest stress, and severe stress, respectively. About 200 women in our study were retested with Chinese Revised Edition of the Social Support Scale and 19-item inventory of stressful life events 2–4 weeks after the first questionnaire survey. The reliabilities were all over 0.85.

Information about each woman's self-reported prepregnancy weight, measured height, and mother's measured weight at the last prenatal visit prior to delivery was collected. Considering the fact that data were collected from developing countries, with only 3.1% (51 of 1,602) and 0.3% (five of 1,602) subjects defined as overweight and obese according to guidelines from the World Health Organization,²⁵ we therefore classified prepregnancy BMI into four categories according to quartiles instead of the standard BMI cutoffs from the World Health Organization. In this study, the gestational BMI gain, not the gestational weight gain, was selected as the indicator of nutrition change during pregnancy because of the fact that the gestational BMI gain showed closer association with OL than the gestational weight gain. Gestational BMI gain was calculated as the difference between maternal BMI

before delivery and prepregnancy BMI. It was categorized as lower, medium-low, medium-high, and high levels by using quartiles.

Data during labor and delivery

Information of delivery mode, infant sex, birth weight, and gestational age at birth was collected from the medical record. The accuracy of scales used to measure birth weight in the hospital was checked using standard weights at the beginning of the study and every 3 months thereafter. Preterm births (births with gestational age <37 completed weeks) were calculated from the gestational age (in completed weeks) based on the difference between the date of the last menstrual period and the date of delivery. These two indicators were also obtained from hospital records. Given the low prevalence of low birth weight in our study (2.5%) as well as the unclear relationship between low birth weight and lactation or breastfeeding, the infant birth weight was categorized as low, medium-low, medium-high, and high levels by using quartiles.

Postpartum data

After delivery, the lactation consultant provided the breastfeeding guidance to women, emphasizing the importance of demand feeding and avoidance of supplements. During the observation of breastfeeding in the hospital, the lactation consultant recorded data on frequency of breastfeeding and lactation on Days 1–3 postpartum. A literal 24 hours was taken as 1 day postpartum. The breastfeeding frequency of less than the 50th percentile (less than three times) was defined as low frequency of breastfeeding. To enhance the accuracy of recalled data, each woman was provided with nursing diary forms for the next 3 days and was encouraged to record the time of each feeding as well as the time when she first felt noticeably fuller in her breasts. Each mother was visited as soon as possible to collect data on the level of breast fullness 72 hours after delivery. It was estimated with a scale by rating scores from 1 (no change) to 3 (noticeably full) to 5 (uncomfortably full). The timing when she felt full in the breasts for a score of 3 (if it had occurred) was recorded as well. Delayed OL was defined as the woman's perception that the breasts were not noticeably full (<3 on the scale) 72 hours after delivery. Maternal perception had been confirmed as a valid public health indicator of lactogenesis stage II.²⁶

In the telephone interview at 2 months postpartum, participants were asked about how they had been feeding and were currently feeding their infants, including the duration of full and any breastfeeding, the use of infant formula or cow's milk, and the introduction of complementary food. The termination of any breastfeeding was defined as ending any breastfeeding and using nonhuman milk without breastfeeding any more. This definition allowed mothers to deviate briefly (1–2 days) from breastfeeding without being considered as having ended breastfeeding.

Data analysis

Student's *t* test and χ^2 analysis were adopted to test the differences in the characteristics of women who were included and excluded in the telephone interview 2 months after delivery.

The potential factors influencing delayed OL included prenatal life events stress during different stages of preg-

nancy, prepregnancy BMI, gestational BMI gain, mode of delivery, infant sex, infant birth weight, gestational age at birth, and frequency of breastfeeding on Day 1 postpartum. These factors were considered as the independent variables and put into the logistic regression model together with delayed OL (as the dependent variable) to evaluate the association between perinatal factors with the onset of lactation. Termination of any breastfeeding 2 months after delivery was the main outcome variable. Delayed OL also acted as an important independent variable in the logistic regression model to explore the association between perinatal factors with termination of breastfeeding. Maternal-level covariates included maternal age, educational attainment, income, and social support during pregnancy.

Crude risk ratios (RRs) and 95% confidence intervals (CIs) were generated for associations of mother–infant pair characteristics with delayed OL and termination of any breastfeeding at 2 months postpartum using univariate logistic regression.

Multiple logistic regression analysis was used to examine the relationship between perinatal variables and delayed OL and the relationship between perinatal variables and termination of breastfeeding after controlling for maternal-level covariates. Maternal-level covariates were forced into the model, and other independent variables were included or removed according to *p* level = 0.10.

Structural equation modeling (SEM) by the analysis of moment structure program was used to evaluate the interaction among variables including independent variables, delayed OL, and termination of any breastfeeding. The modeling was also introduced to test the hypothesis that OL could play a key intermediary role in linking perinatal factors to early termination of any breastfeeding. The relationships among each of the 11 independent variables, two outcome variables, and four covariates were examined respectively. The statistically significant factors were introduced to a preliminary model on the basis of theoretical associations of each variable. In SEM, we used Wald tests to identify nonsignificant paths. Those paths whose removal had increased the χ^2 by the smallest magnitude were dropped out first, and the model was then re-examined. This procedure was repeated until all paths in the model were significant. The relative strength of each hypothesized relationship was indicated by its standardized regression coefficients; these took values in the range –1.0 to +1.0 and could be interpreted as (adjusted) correlation coefficients. The adequacy of the fit of the hypothesized model to the observed data was reported using the model likelihood ratio goodness of fit χ^2 statistic. The following more informative statistics were also reported: the root mean square error of approximation, the value of which should be ≤ 0.08 ; the goodness of fit index, the value of which should be ≥ 0.90 ; the normal fit index, the value of which should be ≥ 0.90 ; and the comparative fit index, the value of which should also be ≥ 0.90 . All analyses were performed using SPSS version 17.0 (SPSS, Inc., Chicago, IL). The power of test ($1 - \beta$) of this study was over 0.9 assuming a significance (α) of 0.05, and a change in response variables of about 5% could be detected.

Results

In total, data on 2,017 eligible mother–infant pairs were collected after delivery at the hospital. Among these pairs,

TABLE 1. CHARACTERISTICS OF MOTHER-INFANT PAIRS ACCORDING TO DELAYED ONSET OF LACTATION AND TERMINATION OF ANY BREASTFEEDING BEFORE 2 MONTHS POSTPARTUM

Characteristic	Number (%) (n = 2,017)	Delayed onset of lactation		Number (%) (n = 1,602)	Termination of any breastfeeding	
		%	RR (95% CI)		%	RR (95% CI)
Mother's age (years)						
20–24	368 (18.2)	6.8	Reference	284 (17.7)	13.4	Reference
25–29	1,272 (63.1)	10.4	1.59 (1.02, 2.48)	1,024 (63.9)	11.8	0.87 (0.59, 1.28)
≥ 30	377 (18.7)	10.9	1.67 (0.99, 2.82)	294 (18.4)	11.2	0.82 (0.50, 1.35)
Mother's education (years)						
≤ 9	292 (14.5)	7.9	0.76 (0.48, 1.19)	217 (13.5)	12.4	1.05 (0.68, 1.62)
> 9	1,725 (85.5)	10.1	Reference	1,385 (86.5)	11.9	Reference
Income ^a						
Lower	295 (14.6)	7.5	0.71 (0.44, 1.13)	230 (14.4)	12.2	1.07 (0.69, 1.66)
Medium	1,488 (73.8)	10.2	Reference	1,180 (73.6)	11.4	Reference
Higher	234 (11.6)	10.3	1.00 (0.64, 1.58)	192 (12.0)	15.1	1.38 (0.89, 2.12)
Social support ^{b,c}						
< 36	443 (22.0)	11.5	1.43 (0.94, 2.16)	343 (21.4)	15.7	1.93 (1.25, 2.99)
36–39	475 (23.5)	9.3	1.12 (0.73, 1.72)	366 (22.8)	13.4	1.60 (1.03, 2.49)
40–43	537 (26.6)	10.4	1.28 (0.85, 1.92)	439 (27.4)	11.2	1.30 (0.84, 2.02)
≥ 44	562 (27.9)	8.4	Reference	454 (28.3)	8.8	Reference
Stressful life events in						
First trimester						
0–1	1,916 (95.0)	9.2	Reference	1,527 (95.3)	11.7	Reference
≥ 2	101 (5.0)	20.8	2.60 (1.56, 4.27)	75 (4.7)	17.3	1.58 (0.85, 2.93)
Second trimester						
0–1	1,955 (96.9)	9.9	Reference	1,558 (97.3)	12.1	Reference
≥ 2	62 (3.1)	8.1	0.80 (0.32, 2.02)	44 (2.7)	9.1	0.73 (0.26, 2.06)
Third trimester						
0–1	1,964 (97.4)	9.9	Reference	1,566 (97.8)	11.6	Reference
≥ 2	53 (2.6)	7.5	0.74 (0.27, 2.09)	36 (2.2)	30.6	3.37 (1.63, 6.96)
Prepregnancy BMI (kg/m ²) ^c						
< 18.44	505 (25.0)	8.7	0.78 (0.51, 1.18)	392 (24.5)	14.5	1.65 (1.06, 2.55)
18.44–19.71	503 (24.9)	8.7	0.78 (0.51, 1.18)	387 (24.2)	11.9	1.31 (0.83, 2.06)
19.72–21.28	503 (24.9)	10.9	Reference	406 (25.3)	9.4	Reference
≥ 21.29	506 (25.1)	10.9	0.99 (0.67, 1.48)	417 (26.0)	12.2	1.35 (0.86, 2.10)
Gestational BMI gain (kg/m ²) ^c						
< 5.27	496 (24.6)	7.5	0.86 (0.54, 1.35)	384 (24.0)	10.7	0.98 (0.63, 1.54)
5.27–6.40	507 (25.1)	8.5	0.99 (0.63, 1.53)	409 (25.5)	11.0	1.02 (0.65, 1.58)
6.41–7.61	512 (25.4)	8.6	Reference	406 (25.3)	10.8	Reference
≥ 7.62	502 (24.9)	14.7	1.84 (1.24, 2.73)	403 (25.2)	15.4	1.50 (0.99, 2.26)
Mode of delivery						
Vaginal delivery	776 (38.5)	5.4	Reference	611 (38.1)	7.5	Reference
Cesarean section	1,241 (61.5)	12.6	2.51 (1.76, 3.58)	991 (61.9)	14.7	2.12 (1.50, 3.01)
Infant sex						
Male	1,044 (51.8)	10.0	Reference	823 (51.4)	13.0	Reference
Female	973 (48.2)	9.7	0.97 (0.72, 1.30)	779 (48.6)	10.9	0.82 (0.60, 1.11)
Birth weight (g) ^c						
< 3,100	483 (23.9)	8.3	0.96 (0.61, 1.51)	372 (23.2)	14.2	1.36 (0.89, 2.09)
3,100–3,399	517 (25.6)	9.3	1.09 (0.71, 1.68)	406 (25.3)	13.5	1.29 (0.84, 1.96)
3,400–3,649	489 (24.2)	8.6	Reference	405 (25.3)	10.9	Reference
≥ 3,650	528 (26.2)	12.9	1.57 (1.05, 2.36)	419 (26.2)	9.5	0.87 (0.55, 1.36)
Gestation						
Term birth	1,907 (94.5)	9.9	Reference	1,524 (95.1)	11.5	Reference
Preterm birth	110 (5.5)	8.2	0.81 (0.40, 1.63)	78 (4.9)	20.5	1.98 (1.12, 3.50)
Breastfeeding frequency on Day 1 ^d						
< 3	834 (41.3)	14.4	2.38 (1.76, 3.21)	667 (41.6)	16.2	1.96 (1.44, 2.65)
≥ 3	1,183 (58.7)	6.6	Reference	935 (58.4)	9.0	Reference
Total	2,017	9.8		1,602	12.0	

^aIncome was categorized as lower, medium, or higher according to perceived status.

^bSocial support was defined as that one had availability of assistance if needed or had received actual received assistance, which included companionship or emotional, tangible, informational support. It was assessed using the Chinese Revised Edition of the Social Support Scale.²³ This scale included including 10 items with the total score ranging from 12 to 64. The higher the score was, the more psychosocial resources people would have.

^cSocial support, prepregnancy body mass index (BMI), gestational BMI gain, and birth weight were categorized by using quartiles.

^dBreastfeeding frequency on Day 1 was categorized by using dichotomy.

CI, confidence interval; RR, risk ratio.

TABLE 2. LOGISTIC REGRESSION MODEL FOR THE ASSOCIATION OF PERINATAL FACTORS WITH DELAYED ONSET OF LACTATION IN 2,017 MOTHER-INFANT PAIRS

Independent variable	RR (95% CI)	
	Model 1 ^a	Model 2 ^b
Life events in the first trimester		
0–1	Reference	Reference
≥2	2.66 (1.58, 4.50)	2.59 (1.52, 4.40)
Gestational BMI gain (kg/m ²) ^c		
<5.27	0.94 (0.59, 1.51)	0.97 (0.61, 1.55)
5.27–6.40	1.05 (0.67, 1.65)	1.04 (0.67, 1.64)
6.41–7.61	Reference	Reference
≥7.62	1.86 (1.24, 2.79)	1.90 (1.27, 2.86)
Mode of delivery		
Vaginal delivery	Reference	Reference
Cesarean section	2.14 (1.48, 3.08)	2.11 (1.46, 3.05)
Breastfeeding frequency on Day 1 ^d		
<3	2.17 (1.60, 2.95)	2.14 (1.57, 2.91)
≥3	Reference	Reference

^aModel 1 is a crude estimate of independent variables on delayed onset of lactation.

^bModel 2 is adjusted in that maternal age, education, income, and social support during pregnancy were forced into the model and other independent variables were included or removed according to *p* level=0.10.

^cGestational body mass index (BMI) gain was categorized by using quartiles.

^dBreastfeeding frequency on Day 1 was categorized by using dichotomy.

CI, confidence interval; RR, risk ratio.

1,602 received valid investigation of breastfeeding behavior, and 415 were excluded at 2 months postpartum. There was no significant difference in the characteristics of mother–infant pairs between those included and excluded.

The characteristics of the 2,017 mother–infant pairs are shown in Table 1. Of the women, 9.8% had experienced delayed OL. The prevalence was reported to be the highest (20.8%) among women who experienced severe life events in the first trimester of pregnancy. In bivariate analyses, delayed OL was significantly associated (*p*<0.05) with maternal age being 25–29 years, experiencing severe life events in the first trimester, gestational BMI gain of ≥7.62 kg/m², cesarean section, infant birth weight ≥3,650 g, and frequency of breastfeeding less than three times on Day 1 postpartum.

The mean rate of termination of any breastfeeding at 2 months postpartum was 12.0%. The rate was reported to be the highest (30.6%) among women who experienced severe life events in the third trimester of pregnancy. In bivariate analyses, termination of any breastfeeding was significantly associated (*p*<0.05) with experiences of severe life events in the third trimester, prepregnancy BMI <18.44 kg/m², low and medium-low social support, cesarean section, preterm birth, and frequency of breastfeeding less than three times on Day 1 postpartum.

In the multiple logistic regression model (Table 2), after controlling for maternal-level covariants (maternal age, education, income, and social support during pregnancy), delayed OL was found to be significantly associated (*p*<0.05) with experiences of severe life events in first trimester (adjusted RR 2.59), gestational BMI gain ≥7.62 kg/m²

TABLE 3. LOGISTIC REGRESSION MODEL FOR THE ASSOCIATION OF PERINATAL FACTORS WITH THE TERMINATION OF ANY BREASTFEEDING WITHIN 2 MONTHS POSTPARTUM IN 1,602 MOTHER-INFANT PAIRS

Independent variable	RR (95% CI)	
	Model 1 ^a	Model 2 ^b
Life events in the third trimester		
0–1	Reference	Reference
≥2	3.61 (1.70, 7.66)	3.44 (1.61, 7.37)
Prepregnancy BMI (kg/m ²) ^c		
<18.44	1.93 (1.23, 3.04)	1.88 (1.19, 2.97)
18.44–19.71	1.41 (0.89, 2.26)	1.40 (0.87, 2.25)
19.72–21.28	Reference	Reference
≥21.29	1.38 (0.87, 2.19)	1.38 (0.87, 2.18)
Gestational BMI gain (kg/m ²) ^c		
<5.27	1.10 (0.69, 1.76)	1.10 (0.68, 1.76)
5.27–6.40	0.97 (0.62, 1.53)	0.96 (0.61, 1.52)
6.41–7.61	Reference	Reference
≥7.62	1.59 (1.04, 2.44)	1.56 (1.02, 2.39)
Gestation		
Term birth	Reference	Reference
Preterm birth	1.91 (1.04, 3.51)	1.81 (0.97, 3.36) ^e
Mode of delivery		
Vaginal delivery	Reference	Reference
Cesarean section	1.95 (1.36, 2.81)	2.06 (1.42, 2.97)
Breastfeeding frequency on Day 1 ^d		
<3	1.66 (1.21, 2.28)	1.62 (1.18, 2.22)
≥3	Reference	Reference
Onset of lactation		
Normal	Reference	Reference
Delayed	2.26 (1.48, 3.44)	2.24 (1.46, 3.44)

^aModel 1 is a crude estimate of independent variables and delayed onset of lactation on termination of any breastfeeding.

^bModel 2 is adjusted in that maternal age, education, income, and social support during pregnancy were forced into the model and other independent variables and delayed onset of lactation were included or removed according to *p* level=0.10.

^cPrepregnancy body mass index (BMI) and gestational BMI gain were categorized by using quartiles.

^dBreastfeeding frequency on Day 1 was categorized by using dichotomy.

^e*p*=0.061.

CI, confidence interval; RR, risk ratio.

(adjusted RR 1.90), cesarean section (adjusted RR 2.11), and frequency of breastfeeding less than three times on Day 1 postpartum (adjusted RR 2.14).

As shown in Table 3, after for controlling maternal-level covariants, termination of any breastfeeding was significantly associated (*p*<0.05) with experiences of severe life events in the third trimester (adjusted RR 3.44), prepregnancy BMI <18.44 kg/m² (adjusted RR 1.88), gestational BMI gain ≥7.62 kg/m² (adjusted RR 1.56), cesarean section (adjusted RR 2.06), frequency of breastfeeding less than three times on Day 1 postpartum (adjusted RR 1.62), and delayed OL (adjusted RR 2.24).

The path diagram with standardized regression coefficients was produced in the final model of SEM (Fig. 1). This final model appropriately fit the data according to the criteria of Hu and Bentler.²⁷ The following findings were obtained from the model: (1) Women with greater

FIG. 1. The final structural equation modeling and observed paths among the measures. $\chi^2=32.78$ and $p=0.003$ ($n=1,602$), root mean square error of approximation=0.029, goodness of fit index=0.995, comparative fit index=0.993, normal fit index=0.924. All paths were significant at $P \leq 0.05$. Path coefficients are standardized. BMI, body mass index.

gestational BMI gain, higher score of stressful life events in the first trimester, cesarean section, and lower frequency of breastfeeding on Day 1 postpartum are predisposed to experience late OL, which could result in an earlier breastfeeding termination. (2) Women with greater gestational BMI gain were also more likely to have a cesarean section, which would lead to delayed OL directly or indirectly through reducing frequency of breastfeeding on Day 1 postpartum, resulting in early termination of breastfeeding finally. (3) Women with higher self-perceived stress of life events in the first trimester were apt to deliver earlier and have a reduced frequency of breastfeeding on Day 1 postpartum, which could postpone the initiation of OL and finally resulted in early termination of breastfeeding. These significant paths supported the hypothesis that OL could play a key role in linking perinatal factors to breastfeeding behavior postpartum.

Discussion

In the present study, the findings indicated that delayed OL was involved in and mediated the relationship between perinatal biopsychosocial risk factors and termination of any breastfeeding. It also confirmed that women with lower pre-pregnancy BMI or exposure to severe life events stress during pregnancy had a significantly increased risk of early termination of any breastfeeding.

The findings showed that the rate of delayed OL was 9.8%. This is the first report so far from an Asian population and close to that reported from Guatemalan women (10–11.7%)¹² and Australian women²⁸ but much lower than that in the United States (22–35%).^{14,29} This wide variation in the incidence of delayed OL among countries may be attributed to ethnic variations or cultural differences.

Findings from SEM confirmed that almost all risk factors in the final model, excluding exposure to stressful life events in the third trimester, indirectly influenced breastfeeding duration through prolonging the lactogenesis. The results are the first to demonstrate that delayed OL, as a negative biological event resulted from biopsychosocial stressors directly or indirectly, could play a key role in bridging prenatal detrimental risks with the change of breastfeeding behavior

postpartum, although the biological mechanisms in these relationships are still unclear.

Research from developed countries^{20–22} has confirmed the association of obesity before pregnancy with shorter breastfeeding duration and presumed that underweight mothers may not be at increased risk of short breastfeeding duration. The present study from China, where there are more underweight women before pregnancy than in developed areas, has suggested that underweight before pregnancy (prepregnancy BMI <18.44 kg/m², similar to the definition of underweight according to the criteria of the World Health Organization²⁵ and the Institute of Medicine³⁰), like obese population in other studies, also has a negative effect on breastfeeding duration. There, more attention should be paid to women who experienced malnutrition or extensive weight control prior to pregnancy. Additionally, this study also showed the positive correlation between gestational BMI gain with cesarean section frequency in samples with low prevalence of obesity and that the RR value between delayed OL and early termination of any breastfeeding in women with cesarean section was more than twice that in women with vaginal delivery. Taking into account the extreme high prevalence of cesarean section (above 60% in our study) and its negative effects on lactation postpartum, it would be effective to improve the breastfeeding practice in China through controlling excessive weight gain during pregnancy and decreasing the utilization of cesarean section.

It is indicated from this study that maternal exposure to severe life events in the third trimester, not the second trimester, was significantly associated with increased risk of early termination of any breastfeeding. The results were partly inconsistent with those from the report of Li et al.,³¹ in which they demonstrated that women who experienced stressful life events in both the second and third trimesters were more likely to stop breastfeeding within 4 months after delivery. One reason for the inconsistency may be the different definition of a stressful life event. It is interesting that our result from SEM clearly indicated that exposure to severe life events in the first trimester also increased the risk of early termination of any breastfeeding indirectly by increasing the risk of delay OL and preterm birth.

Furthermore, it is noteworthy that in this study, the association between experiences of severe life events associated with delayed OL and early termination of breastfeeding was much stronger than other risk factors using multiple logistic regression models. The adjusted RR between experiences of stressful life events in the first trimester with OL was 2.59, and the adjusted RR between experiences of stressful life events in the third trimester with early termination of any breastfeeding was 3.44.

In this study involving participants from the same region and having similar cultural backgrounds, confounding effects resulted from severe biomedical factors on initiation and duration of breastfeeding are controlled through strict selection criteria for subjects. SEM also allows more intricate patterns of interrelationships between variables to be explored than is possible with standard regression methods.

There are still some limitations in our study. First, recall bias is inevitable in our study, even though it has been reduced to a great extent. Second, some women have used supplemental fluids such as water, glucose water, or formula without surveillance, which is not in compliance with the requirement of breastfeeding guidelines and inhibited in the hospital. The additional utilization of supplements might be a potential confounder in the association between other perinatal risk factors and delayed OL. The third limitation is the absence of data on initiation of breastfeeding in the first hour after birth, maternal breastfeeding confidence, and breastfeeding plan, which may be related to breastfeeding duration. Given that stress is culturally defined/influenced, more caution should be warranted in generalizing our findings beyond the region/culture being studied.

Conclusions

The present study suggests that delayed OL puts infants at significantly greater hazard of ending breastfeeding by 2 months postpartum. More important is that our results provide evidence that delayed OL, as a negative biological event resulted from perinatal biopsychosocial stress directly or indirectly, is a key mediator linking perinatal stressors to the change of breastfeeding behavior 2 months postpartum. The findings will be helpful to illuminate the significance of the appropriate OL timing supported by healthcare providers in improving maternal breastfeeding behavior. It is also recommended that mother–infant pairs be followed up 72 hours after delivery and that mothers with initiation of lactation difficulties should be provided with immediate assistance by health professionals trained in lactation management. Additionally, underweight before pregnancy and experiences of severe life events during the first and third trimesters significantly increased the risk of early termination of any breastfeeding, a finding that should attract more attention and deserves further in-depth investigations.

Acknowledgments

This study was funded by the Key Projects in the National Key Technologies R&D Program (grant 2006BAI05A03), the National Natural Science Foundation of China (grants 81072310, 30901203, and 30901202), and the Research Fund for the Doctoral Program of Anhui Medical University (grant XJ201019). We are extremely grateful to the mothers and in-

fants who participated in the study. The authors would also like to thank the staff members of Hefei Maternal and Child Health Hospital and the investigators and persons responsible for the data collection.

Disclosure Statement

No competing financial interests exist.

References

1. Kramer MS, Kakuma R. The optimal duration of exclusive breastfeeding: A systematic review. *Adv Exp Med Biol* 2004;554:63–77.
2. World Health Organization. *Global Strategy on Infant and Young Child Feeding*. World Health Organization, Geneva, 2003.
3. Gartner LM, Morton J, Lawrence RA, et al. Breastfeeding and the use of human milk. *Pediatrics* 2005;115:496–506.
4. Fu Z, Chang S, He W, et al. Exclusive breastfeeding and growth of infants under 4 months in China [in Chinese]. *Wei Sheng Yan Jiu* 2000;29:275–278.
5. Qiu L, Zhao Y, Binns CW, et al. Initiation of breastfeeding and prevalence of exclusive breastfeeding at hospital discharge in urban, suburban and rural areas of Zhejiang China. *Int Breastfeed J* 2009;4:1.
6. Baxter J, Cooklin AR, Smith J. Which mothers wean their babies prematurely from full breastfeeding? An Australian cohort study. *Acta Paediatr* 2009;98:1274–1277.
7. Donath SM, Amir LH. Effect of gestation on initiation and duration of breastfeeding. *Arch Dis Child Fetal Neonatal Ed* 2008;93:F448–F450.
8. Grajeda R, Perez-Escamilla R. Stress during labor and delivery is associated with delayed onset of lactation among urban Guatemalan women. *J Nutr* 2002;132:3055–3060.
9. Li R, Jewell S, Grummer-Strawn L. Maternal obesity and breast-feeding practices. *Am J Clin Nutr* 2003;77:931–936.
10. Raj VK, Plichta SB. The role of social support in breastfeeding promotion: A literature review. *J Hum Lact* 1998; 14:41–45.
11. Scott JA, Binns CW, Oddy WH, et al. Predictors of breastfeeding duration: Evidence from a cohort study. *Pediatrics* 2006;117:E646–E655.
12. Hruschka DJ, Sellen DW, Stein AD, et al. Delayed onset of lactation and risk of ending full breast-feeding early in rural Guatemala. *J Nutr* 2003;133:2592–2599.
13. Chapman DJ, Perez-Escamilla R. Does delayed perception of the onset of lactation shorten breastfeeding duration? *J Hum Lact* 1999;15:107–111.
14. Dewey KG, Nommsen-Rivers LA, Heinig MJ, et al. Risk factors for suboptimal infant breastfeeding behavior, delayed onset of lactation, and excess neonatal weight loss. *Pediatrics* 2003;112:607–619.
15. Chen DC, Nommsen-Rivers L, Dewey KG, et al. Stress during labor and delivery and early lactation performance. *Am J Clin Nutr* 1998;68:335–344.
16. Altemus M, Deuster PA, Galliven E, et al. Suppression of hypothalamic-pituitary-adrenal axis responses to stress in lactating women. *J Clin Endocrinol Metab* 1995;80:2954–2959.
17. Neumann ID, Torner L, Wigger A. Brain oxytocin: Differential inhibition of neuroendocrine stress responses and anxiety-related behaviour in virgin, pregnant and lactating rats. *Neuroscience* 2000;95:567–575.

18. Torner L, Neumann ID. The brain prolactin system: Involvement in stress response adaptations in lactation. *Stress* 2002;5:249–257.
19. Neumann ID, Torner L, Wigger A. Brain oxytocin: Differential inhibition of neuroendocrine stress responses and anxiety-related behaviour in virgin, pregnant and lactating rats. *Neuroscience* 2000;95:567–575.
20. Baker JL, Michaelsen KF, Sorensen TI, et al. High pre-pregnant body mass index is associated with early termination of full and any breastfeeding in Danish women. *Am J Clin Nutr* 2007;86:404–411.
21. Hilson JA, Rasmussen KM, Kjolhede CL. Excessive weight gain during pregnancy is associated with earlier termination of breast-feeding among white women. *J Nutr* 2006;136:140–146.
22. Giovannini M, Radaelli G, Banderali G, et al. Low pre-pregnant body mass index and breastfeeding practices. *J Hum Lact* 2007;23:44–51.
23. Xiao SY. Theoretical principle and application of social support scale. *J Clin Psychiatry* 1994;4:98–100.
24. Zhu P, Tao F, Hao J, et al. Prenatal life events stress: Implications for preterm birth and infant birthweight. *Am J Obstet Gynecol* 2010;203:34.E1–E8.
25. World Health Organization. *Obesity: Preventing and Managing the Global Epidemic*. World Health Organization, Geneva, 1998.
26. Chapman DJ, Perez-Escamilla R. Maternal perception of the onset of lactation is a valid, public health indicator of lactogenesis stage II. *J Nutr* 2000;130:2972–2980.
27. Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Struct Equ Modeling* 1999;6:1–55.
28. Scott JA, Binns CW, Oddy WH. Predictors of delayed onset of lactation. *Matern Child Nutr* 2007;3:186–193.
29. Chapman DJ, Perez-Escamilla R. Identification of risk factors for delayed onset of lactation. *J Am Diet Assoc* 1999;99:450–454.
30. Institute of Medicine (Subcommittees on Nutritional Status and Weight Gain During Pregnancy and Dietary Intake and Nutrient Supplements During Pregnancy, Committee on Nutritional Status During Pregnancy and Lactation, Food and Nutrition Board). *Nutrition During Pregnancy: Part I, Weight Gain; Part II, Nutrient Supplements*. National Academies Press, Washington, DC, 1990.
31. Li J, Kendall GE, Henderson S, et al. Maternal psychosocial well-being in pregnancy and breastfeeding duration. *Acta Paediatr* 2008;97:221–225.

Address correspondence to:

Fangbiao Tao, PhD, MD
 Department of Maternal and Child Health
 School of Public Health
 Anhui Medical University
 81 Meishan Road
 Hefei 230032, China

E-mail: fbtao@ahmu.edu.cn