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# A comparative study of cumulative stress patterns within 14 days postpartum in healthy mothers and those with gestational diabetes

## A prospective study

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**Abstract**

Although the number of mothers with gestational diabetes mellitus (GDM) is on the rise, only few studies have examined the cumulative stress associated with breastfeeding after childbirth. GDM mothers are susceptible to stress due to insulin resistance, and their level of stress is associated with breastfeeding. This study aimed to identify patterns of stress change over time in GDM mothers and healthy mothers and to identify the factors influencing those patterns.

The participants of this study were mothers within 14 days after childbirth. The GDM group consisted of 32 mothers, and the healthy group comprised 30 mothers. Cumulative stress was measured in terms of heart rate variability, and linear mixed models were used to analyze changes over time.

The cumulative stress of healthy mothers was about 8 points higher than that of mothers with GDM ($t = -2.95$, $P = .005$). The cumulative stress level was inversely associated with the mother's age (β=-1.20, $P = .018$), the mother's weight (β=-0.64, $P = .008$), and the baby's body mass index (β=-3.09, $P = .038$). Furthermore, an insufficient amount of breast milk was associated with higher stress (β=16.09, $P = .007$).

GDM mothers and healthy mothers experienced different patterns of cumulative stress. Breastfeeding should be started quickly to promote health and stress reduction among mothers who are physically and psychologically vulnerable after childbirth.

It is necessary to incorporate programs to promote breastfeeding considering stress levels at an appropriate time according to the mother's health condition.

**Abbreviations:** BMI = body mass index, GDM = gestational diabetes mellitus, HRV = heart rate variability.

**Keywords:** diabetes, breast feeding, gestational, physiological response, stress, women's health

## 1. Introduction

### 1.1. Background

It is estimated that 20.4 million people – corresponding to 15.8% of births – experienced hyperglycaemia during pregnancy, of which 83.6% were due to gestational diabetes mellitus (GDM) in 2019.[1] The prevalence of GDM rapidly increases with age, to the point that it occurs in 37.0% of pregnancies in women aged 45 or older versus 10% to 15% of pregnancies in women under the age of 30; social changes have led to pregnancies occurring at older ages, increasing the overall population-level burden of GDM.[1] As the number of mothers with GDM has increased,

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complications such as difficulty giving birth, premature birth, and fetal death due to overweight or large infants are on the rise.[1,2] Mothers with GDM are much more likely to develop chronic diseases such as high blood pressure, heart disease, type 2 diabetes, and cancer. Furthermore, children of mothers with GDM are more likely to develop obesity and type 2 diabetes.[2,3] For this reason, mothers with GDM need regular care including diet, exercise, and stress management; within this context, breastfeeding positively affects both mothers and babies.[4]

Breastfeeding has been reported to improve women's health and affect the healthcare costs of newborns.[5] According to a systematic review and meta-analysis of 163 previous studies on breastfeeding and maternal health, breastfeeding for more than 1 year reduced the risk of breast cancer (26%) and ovarian cancer (37%).[3] Moreover, a short duration of breastfeeding was strongly associated with postpartum depression.[3] A previous study examining the average medical cost of newborns who were fed using different methods showed that the medical expenses of exclusively-breastfed newborns were significantly lower.[5] Another study reported that breastfeeding also has implications for adult life. In 3493 newborns, breastfeeding experience was associated with a higher intelligence quotient (IQ) after 30 years, affecting educational achievement and income in adulthood.[6]

The World Health Organization recommends breastfeeding at least 6 months. In general, both healthy mothers and mothers with GDM plan to breastfeed because of the benefits of breastfeeding.[7] However, two-thirds of children are not breastfed as recommended.[8] A previous study examined the reasons for which 1323 healthy mothers stopped breastfeeding within 1 year, and the 3 main reasons were that the baby started biting, lost interest in breast milk, and the mother could not produce enough breast milk.[9] In a study of 505 mothers, the most significant factor associated with stopping breastfeeding was physical difficulties, including lack of milk and exhaustion.[10] Unlike healthy mothers, mothers with GDM take several days to supply a sufficient amount of breast milk because of insulin resistance and improper blood sugar control, which cause delays in milk production.[2] In addition, mothers with GDM are pathologically susceptible to infection and stress due to increased insulin resistance,[11,12] and newborns of mothers with GDM are known to have a higher risk of breathing difficulties associated with maternal depression and emotional stress.[13]

Most studies have focused on reasons for stopping breastfeeding in healthy mothers,[9,10] whereas few studies have investigated breastfeeding in mothers with GDM, who are thought to be under considerable physical and psychological stress. Thus, the purpose of this study was to reflect the growing reality of mothers with GDM by investigating patterns of stress over time and identifying factors influencing those stress patterns in mothers with GDM and healthy mothers.

### 1.2. Purpose and research question

The short-term prospective study was conducted to identify factors affecting stress in mothers with GDM and healthy mothers. The research questions for this study are listed below.

Research question 1: Is there a difference in stress levels between the GDM group and healthy mothers?

Research question 2: How does the stress level change in the GDM group and healthy mothers over time?

## 2. Methods

### 2.1. Data collection from the participants

In this prospective research study, data collection date took place from May 25, 2020 to June 21, 2021. The inclusion criterion was participants who breastfed at least 2 weeks after childbirth; mothers who stopped breastfeeding during this period were excluded from the study. The study participants were volunteers drawn from patients at a prenatal breastfeeding clinic located in South Korea. After giving birth, mothers who agreed to participate in the study contacted the research team and informed the team of their childbirth.

Researchers visited participants within 5 and 14 days after childbirth to investigate the characteristics of breastfeeding, participants' general characteristics, and their cumulative stress measured in terms of heart rate variability (HRV). This timing was chosen because human breast milk is divided into 3 types according to the secretion period and composition: breast milk secreted for 5 days after birth is called colostrum, transitional milk is secreted from 5 to 15 days, and mature milk is secreted after 15 days.[14] In the beginning of the study, 33 mothers with GDM and 30 healthy mothers were recruited. One GDM mother dropped out due to loss of contact in the second phase. Therefore, a total of 32 GDM mothers and 30 healthy mothers participated.

### 2.2. Ethics

This study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board of Hoseo University (1041231-200429-HR-110-2). Data collection was conducted after receiving approval from the ethics committee. Written informed consent was obtained from all participants.

### 2.3. Measurements

**2.3.1. Outcome variable: cumulative stress.** In this study, we measured cumulative stress rather than stress at a given moment, considering that participants were in the early stages after childbirth. Cumulative stress was objectively measured using UBio Blip v70 (Bio Sense Creative, Korea), an autonomic nervous system measuring device. This instrument quantifies the state of cumulative stress according to the autonomic nervous system balance based on the measured HRV. HRV refers to subtle changes between 1 cardiac cycle and the next cycle in the degree of heart rate fluctuations. These heart rates are related to the interaction between the sympathetic and parasympathetic nervous systems.[15,16] Cumulative stress is measured from 1 to 100 points, and higher values indicate more exposure to stressful situations.

**2.3.2. Independent variables.** As general demographic characteristics, mothers' age, education level, employment status, and weight were examined. Delivery method: normal spontaneous vaginal delivery or cesarean section and gestation period were analysed as characteristics related to childbirth. Features related to breastfeeding included the baby's body mass index (BMI), the presence or absence of 4 types of discomfort during breastfeeding: breast pain, lack of breast-milk volume, nipple pain, and nipple cracking, the number of breastfeeding sessions per day, the amount and frequency of formula feeding, and the self-reported stress score related to breastfeeding.

### 2.4. Data analysis

Statistical analyses were conducted using SPSS for Windows 10 version 24.0 (IBM Corp., Armonk, New York, NY) as follows. Descriptive statistics were calculated, and the independent t-test and chi-square test were performed to compare the characteristics of each group. Changes and differences in cumulative stress between groups were analysed using the independent *t* test. Linear mixed models were also used to explore the factors affecting cumulative stress between the fifth day and 2 weeks after childbirth. We considered *P* values <.05 as indicating statistical significance.

## 3. Results

### 3.1. Homogeneity of demographic characteristics between groups at baseline

Table 1 shows the demographic characteristics of the study participants. A total of 62 mothers participated in the study, including 32 mothers with GDM and 30 healthy mothers. The mean age of the mothers with GDM was 32.47 ± 7.12 years, and that of the healthy mothers was 31.17 ± 3.67 years. Furthermore, 84.4% of the mothers with GDM and 80% of the healthy mothers had a college education or higher, and 37.5% of mothers with GDM and 30% of healthy mothers were currently employed. The mothers in the 2 groups weighed 67.55 ± 10.51 kg and 65.80 ± 7.77 kg, respectively. Cesarean sections were more common than normal spontaneous vaginal delivery in mothers with GDM (56.3% vs 43.8%, respectively). The BMI of the newborns was 12.55 ± 1.38 kg/m$^2$ and 12.05 ± 1.03 kg/m$^2$ in the 2 groups, respectively. Regarding breastfeeding-related discomfort, healthy mothers had more breast and nipple pain than mothers with GDM. However, a lack of breast milk and nipple cracking were more frequent among mothers with GDM. The number of breastfeeding sessions per day was 4.66 and 4.90 in the 2 groups, respectively, and the amount of additional formula was 218.43 cc and 222.50 cc. The number of formula feeding sessions per day was 4.20 and 4.94 in both groups and the level of self-reported breastfeeding-related stress was 47.26 and 38.26 points. However, there were no statistically significant differences between the groups (Table 1).

### 3.2. The change of cumulative stress measured in terms of HRV

The cumulative stress on the fifth day after childbirth was approximately 2 points higher in mothers with GDM, but this difference was not statistically significant. However, at 2 weeks after birth, the cumulative stress of healthy mothers was about 8 points higher than that of mothers with GDM, which was a statistically significant difference (t = −2.95, *P* = .005) (Table 2 & Fig. 1).

### 3.3. Factors affecting cumulative stress

Table 3 showed the factors affecting the mothers' cumulative stress. The difference in stress between the 2 groups initially

**Table 1**

**Homogeneity of demographic characteristics between groups at baseline.**

| Characteristics | | GDM group (n = 32) M ± SD or n (%) | Control group (n = 30) M ± SD or n (%) | *t* or $X^2$ | *P* |
|---|---|---|---|---|---|
| Age (yr) | | 32.47 ± 7.12 | 31.17 ± 3.67 | 0.90 | .374 |
| Education level | <College/university | 5 (15.6) | 26 (68.4) | 0.01 | .906 |
| | ≥College/university | 27 (84.4) | 6 (20.0) | | |
| Employment status | Yes | 12 (37.5) | 9 (30.0) | 0.13 | .723 |
| | No | 20 (62.5) | 21 (70.0) | | |
| Weight (kg) | | 67.55 ± 10.51 | 65.80 ± 7.77 | 0.74 | .464 |
| Delivery method | Vaginal delivery | 14 (43.8) | 18 (60.0) | 1.05 | .305 |
| | Cesarean section | 18 (56.3) | 12 (40.0) | | |
| Gestational period | | 37.94 ± 1.18 | 38.20 ± 0.96 | −0.96 | .341 |
| Baby's BMI (kg/m$^2$) | | 12.55 ± 1.38 | 12.05 ± 1.03 | 1.44 | .156 |
| Discomfort related to breastfeeding | | | | | |
| Breast pain (yes) | | 9 (28.1) | 12 (40.0) | 0.52 | .472 |
| Lack of breast milk (yes) | | 14 (43.8) | 9 (30.0) | 0.73 | .391 |
| Nipple pain (yes) | | 14 (43.8) | 14 (46.7) | 0.053 | .818 |
| Nipple cracking (yes) | | 10 (31.3) | 7 (23.3) | 0.171 | .679 |
| Number of breastfeeding sessions (/day) | | 4.66 ± 1.79 | 4.90 ± 2.59 | −0.41 | .686 |
| Additional formula (cc/day) | | 218.43 ± 558.86 | 222.50 ± 181.04 | −0.03 | .973 |
| Number of formula feeding sessions | | 4.20 ± 2.95 | 4.94 ± 2.90 | −0.91 | .369 |
| Breastfeeding-related stress self-score | | 47.26 ± 21.63 | 38.26 ± 23.14 | 1.36 | .180 |

BMI = body mass index, GDM = gestational diabetes mellitus.

**Table 2**

**Changes of cumulative stress measured in terms of HRV.**

| Variables | Cumulative stress measured in terms of HRV | | | |
|---|---|---|---|---|
| | GDM | Control | *t* | *P* |
| Baseline | 43.85 ± 12.27 | 41.70 ± 8.93 | 0.76 | .454 |
| Two weeks | 38.76 ± 10.03 | 46.30 ± 9.58 | −2.95 | .005 |

GDM = gestational diabetes mellitus, HRV = heart rate variability.

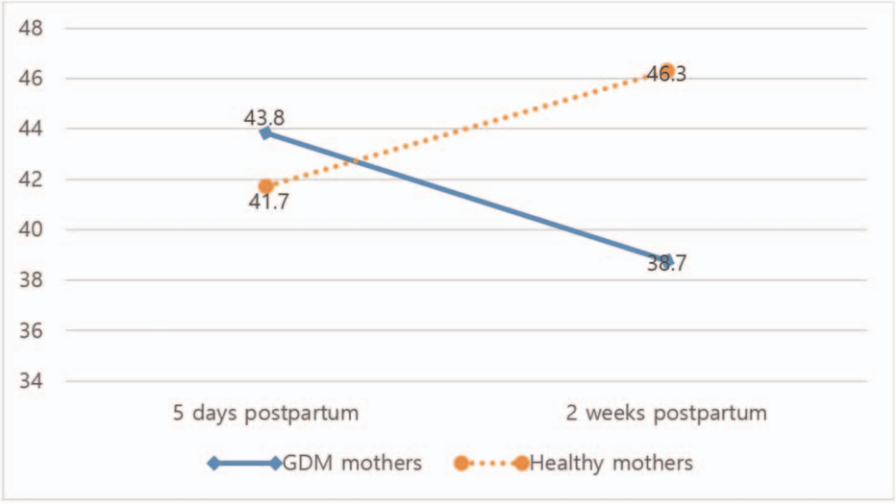


**Figure 1.** Changes in cumulative stress over time. GDM = gestational diabetes mellitus.

showed no statistical significance, but the cumulative stress on the fifth day after birth was lower than that after 2 weeks (β = −17.25, $P = .010$). However, there was no interaction between the groups and time. The factors influencing the mothers' cumulative stress were the mother's age and weight, the baby's BMI, and a lack of breast milk. In other words, the cumulative stress level was lower in older mothers (β = −1.20, $P = .018$) and those with higher weight (β = −0.64, $P = .008$). As the baby's BMI increased, the mother's cumulative stress decreased (β = −3.09, $P = .038$), and an insufficient amount of breast milk was associated with higher stress (β = 16.09, $P = .007$) (Table 3).

## 4. Discussion

This study investigated whether there was a difference in cumulative stress over time between mothers with GDM and healthy mothers. No significant difference was found in cumulative stress between the groups, but a difference did exist over time. Specifically, healthy mothers had higher cumulative stress on the 14th day after childbirth than on the fifth day, whereas this was not the case for GDM mothers.

One of the reasons for this difference in stress over time may relate to the difference in labour methods. Although the difference was not statistically significant, mothers with GDM were more likely to have undergone a cesarean section. In accordance with the present results, previous studies have demonstrated that mothers who delivered through a cesarean section had less breastfeeding intention than the women who gave birth through vaginal delivery.[17,18] These results corroborate the findings of a previous work,[18] which found that women who delivered through a planned cesarean section were 1.61 times more likely to stop breastfeeding before 12 weeks postpartum than women who had a vaginal delivery. This finding also seems to be consistent with other research,[17] which

**Table 3**

**Factors affecting cumulative stress in breastfeeding mothers.**

| Variables | β | SE | *P* | 95% CI | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| Age | −1.20 | 0.46 | .018 | −2.16 | −0.23 |
| <College/university (ref: ≥ college/university) | 5.18 | 4.40 | .253 | −4.02 | 14.38 |
| Employment status (yes) (ref: no) | 6.21 | 4.81 | .212 | −3.85 | 16.27 |
| Weight (kg) | −0.64 | 0.22 | .008 | −1.11 | −0.19 |
| Delivery method, cesarean section (ref: normal delivery) | −4.08 | 3.93 | .312 | −12.30 | 4.14 |
| Gestational period | 7.22 | 2.40 | .007 | 2.20 | 12.24 |
| Baby's BMI (kg/m$^2$) | −3.09 | 1.39 | .038 | −6.00 | −0.19 |
| Breast pain (yes) (ref: no) | 7.17 | 4.91 | .160 | −3.10 | 17.44 |
| Lack of breast milk (yes) (ref: no) | 16.09 | 5.29 | .007 | 5.01 | 27.16 |
| Nipple pain (yes) (ref: no) | −5.78 | 4.32 | .197 | −14.83 | 3.27 |
| Nipple cracking (yes) (ref: no) | −1.15 | 5.11 | .824 | −11.85 | 9.55 |
| Number of breastfeeding sessions (day) | −0.60 | 0.68 | .391 | −2.03 | 0.83 |
| Additional formula (cc/day) | −0.00 | 0.01 | .884 | −0.03 | 0.03 |
| Number of formula feeding sessions | 1.36 | 0.71 | .073 | −0.14 | 2.85 |
| Breastfeeding-related stress | −0.08 | 0.07 | .303 | −0.23 | 0.07 |
| Group | −10.82 | 5.53 | .065 | −22.40 | 0.77 |
| Time | −17.25 | 5.98 | .010 | −29.76 | −4.73 |
| Group × Time | 15.28 | 8.47 | .087 | −2.45 | 33.02 |

BMI = body mass index, CI = confidence interval.

found that women who underwent cesarean sections were less likely to breastfeed due to delayed breastfeeding initiation and the use of formula in the hospital. A previous study analysed the time when breastfeeding began after childbirth among 1225 mothers in 22 Korean hospitals in 2009 and found that no mothers who underwent cesarean sections started breastfeeding within 30 minutes.[17]

Furthermore, breastfeeding began within 2 hours in 24.9% of women who had a vaginal delivery, but only 0.8% of those who underwent a cesarean section.[19] A qualitative study conducted among 27 mothers who experienced childbirth through a cesarean section found that they expressed disappointment at an inability to breastfeed quickly due to pain and distress.[20] For successful breastfeeding, skin-to-skin time immediately after childbirth and early unlimited breastfeeding are strongly encouraged.[21]

Both the GDM and control groups in this study had formula feeding of 200 cc or more per day. Although it is not shown in Table 1, only 4 infants in the GDM group and 9 infants in the control group were exclusively breastfed at 2 weeks after childbirth. This is a significant finding that indicates the difficulties experienced by GDM mothers in practicing exclusive breastfeeding. Prenatal care, including prenatal preparation for breastfeeding, should facilitate exclusive breastfeeding for pregnant women who intend to breastfeed.

Oxytocin, a hormone produced by the hypothalamus and secreted by blood circulation during breastfeeding, reduce stress hormones such as cortisol.[22,23] Summarizing the mechanisms underlying the relationships among oxytocin, breastfeeding, and stress in previous studies, secreted oxytocin causes the myoepithelial cells surrounding the mammary gland alveoli to contract, thereby relaxing the ductal sphincter and promoting milk excretion. Furthermore, sucking by the baby stimulates the release of oxytocin from nerves in the brain and contributes to stress reduction through a strong antistress effect.[22,24] A systematic analysis of the results of 29 previous studies reported that women exposed to various types of stress secrete less oxytocin in response to breastfeeding than mothers who were not exposed to stressors.[23] Therefore, breastfeeding should be started quickly to promote health and stress reduction among mothers who are physically and psychologically vulnerable after childbirth.

No previous study investigated changes in stress among mothers with GDM in a way directly comparable to this study. However, prior research has reported that postpartum stress in healthy mothers varies with time. In a cohort study that investigated stress 2 and 6 months after childbirth among 513 healthy first-time mothers living at home during the study period, it was reported that stress decreased 6 months after childbirth.[25] In this study, the cumulative stress of the GDM mothers after 2 weeks was significantly lower than that of the control group. Most GDM mothers were unable to start breastfeeding smoothly even at the second week after childbirth for reasons such as a lack of milk. In contrast, the mothers of the control group were likely to experience breast engorgement and sleep disturbances as they actively participated in breastfeeding, which consumes physical energy. This is likely to increase the cumulative stress in the control group. Nurses should be aware of the likelihood of delayed breastfeeding initiation for GDM mothers as a component of postpartum care and should actively encourage breastfeeding.

In this study, the factors found to affect cumulative stress were the mother's age and weight, gestation period, the baby's BMI, and a lack of breast milk. In recent years, most Korean women have used postpartum care centres for 3 weeks after childbirth, and during this period, they engage in postpartum rest and recovery.[26] A previous study showed that during this period, a program provided by the postpartum care centre increases confidence in maternal roles and the success rate of breastfeeding 4 to 6 weeks after birth.[27] The participants in this study were mothers within 2 weeks of childbirth who had not yet fully recovered postpartum, so prepartum conditions such as age, weight, and gestation period may have influenced mothers' cumulative stress. This is also a transitional time regarding confidence in the maternal role and the success of breastfeeding. Babies' weight is a very sensitive issue for mothers, and previous studies have reported that the baby's birth weight affected the mother's chronic stress.[28,29] Besides, maternal stress and breastfeeding are very closely related, and breastfeeding has been found to reduce maternal stress.[3,30] Insufficient amounts of breast milk and low BMI in babies can cause stress in mothers; thus, further studies are needed to compare changes in breastfeeding and stress over time in the future.

This study has the following limitations. First, this study did not include information on when the mother began breastfeeding or personal factors such as the mother's parenting experience. Furthermore, the follow-up was limited to only 2 weeks, which means the findings may not have covered the entire scope of cumulative stress changes in the postpartum recovery period. Second, although a difference in stress over time was confirmed between mothers with GDM and healthy mothers, longer-term repeated observations are required to rule out various biases and clarify the implications of these findings. Finally, the effect of a lack of breast milk on maternal stress was confirmed, but the composition of nutrients in the breast milk and the babies' BMI were not investigated. Further research will be necessary to determine the relationship between maternal stress and milk composition. However, despite these limitations, the meaningful findings of the present study form a basis for possible effective interventions in the future by observing changes in cumulative stress in early postpartum mothers.

## 5. Conclusion

Mothers with GDM and healthy mothers experienced different levels of cumulative stress over time. Therefore, it is necessary for healthcare providers to apply a program that can promote breastfeeding at an appropriate time according to the mother's health condition.

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## Author contributions

Conceptualization, S.P. and D.M.; methodology, S.P. and D.M.; software, D.M.; validation, S.P. an; formal analysis, D.M.; investigation, S.-Y.Y. and E.K; resources, S.P.; data curation, D. M.; writing – original draft preparation, D.M.; writing – review and editing, S.P. and S.-Y.Y.; visualization, D.M.; supervision, S.

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**Methodology:** Deulle Min.
**Supervision:** Seungmi Park.
**Visualization:** Deulle Min.
**Writing – original draft:** Deulle Min.
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