Comprehensive Psychoneuroendocrinology 8 (2021) 100085

Contents lists available at ScienceDirect

Comprehensive Psychoneuroendocrinology

journal homepage: www.sciencedirect.com/journal/comprehensive-psychoneuroendocrinology

# The relationship between prenatal attachment and postnatal adaptation, maternal anxiety and breast milk sodium level

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ARTICLE INFO

*Keywords:*
Prenatal attachment
Breast milk sodium
Perinatal psychosocial factors

ABSTRACT

*Objective:* To investigate the relationship between maternal-fetal attachment and breast milk sodium (BMS) levels.
*Methods:* This prospective case-control study was conducted at Baskent University. Third-trimester low-risk pregnancies were included in the study. After obtaining informed consent, the Prenatal Attachment Inventory (PAI), and the State-Trait Anxiety Inventory 1 (STAI 1) and STAI 2 were administered. After delivery, BMS values were measured at regular intervals.
*Results:* The mean age of the mothers and the mean gestational age were 29.6 $\pm$ 3.4 years and 38.4 $\pm$ 0.9 weeks, respectively. The mean STAI -1, STAI-2, and PAI scores were 38.2 $\pm$ 7.1, 38.8 $\pm$ 6.9, and 41.6 $\pm$ 10, respectively. When the study group was classified according to BMS levels, no differences were observed between the groups in terms of pregnancy STAI-1, pregnancy STAI-2, Muller PAI, and STAI-1 scores of the 5$^{th}$, 15$^{th}$, and 30$^{th}$ days. There was no correlation between the BMS levels on the 5$^{th}$ –15$^{th}$ days and pregnancy STAI-1, Pregnancy STAI-2, Muller PAI, and the STAI-1 scores of the 5$^{th}$-10$^{th}$-30$^{th}$ days. However, the BMS level on the 30$^{th}$ day had a positive significant correlation with the STAI-1 score on the 15$^{th}$ day ($r = 0.473$, $p= .006$). Additionally, the STAI-1 scores on the 30$^{th}$ day showed that there was a significant correlation with STAI-1 on the 5$^{th}$ day ($r = 0.416$, $p= .015$), STAI-1 on the 15$^{th}$ day ($r = 0.497$, $p= .003$), and breast milk sodium levels on the 30$^{th}$ day ($r = 0.615$, $p< .001$).
*Conclusion:* We found no relationship between PAI scores and BMS levels on the 5$^{th}$-10$^{th}$-30$^{th}$ day but STAI scores on the 15$^{th}$ day and 30$^{th}$ day had a positive correlation with BMS levels on the 30$^{th}$ day. STAI-1 and STAI-2 scores during pregnancy were positively correlated with STAI scores in the postnatal period.

## 1. Introduction

Prenatal attachment is the special relationship formed between the mother and the baby during pregnancy. The most recent definition proposed by Doan and Zimerman is that "prenatal attachment is an abstract concept that represents the filial relationship between a pregnant mother and her fetus, and is related to the cognitive and emotional abilities to conceptualize another human being, which may even begin before gestation" [1]. Prenatal attachment is a process that develops during pregnancy as a result of dynamic psychologic and physiologic events. The magnitude of the relationship between mother and fetus may be affected by many variables such as maternal demographic factors, health status, gestational history, anxiety, depression, and perceived support during the pregnancy. This relationship is expected to be strongest in the third trimester of pregnancy, with the expectation that the pregnancy approaches the end and a healthy individual joins the family. Also, having high socioeconomic status and accessing timely and comprehensive prenatal care support prenatal attachment [2–4].

Prenatal attachment is important because it is related to healthier mother behavior during pregnancy, less postnatal anxiety and depression, it is a good predictor of the early bond between mother and child [5,6] and competence in infant feeding [7], and it is correlated with the mother's sensitivity in the interaction with the newborn [6,8,9]. Also, it is an indicator of the initiation, continuity, and duration of breastfeeding

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https://doi.org/10.1016/j.cpnec.2021.100085
Received 28 May 2021; Received in revised form 31 August 2021; Accepted 2 September 2021
Available online 8 September 2021

[10].

Due to its unique composition, breast milk is a human right for every baby, and breastfeeding is strongly recommended. Successful milk production and the composition of breast milk are often negatively affected by stress, because oxytocin, which stimulates the milk ejection reflex, is frequently affected by emotional disturbances [11]. Although the clinical importance of elevated breast milk sodium is unclear, the decrease in breast milk sodium (BMS) each day after birth is known to be associated with successful lactation [12,13]. Elevated anxiety during the postnatal period is correlated with higher BMS [11]. Additionally, maternal motivation for breastfeeding, maternal educational level, lifestyle, family support, and the presence of psychiatric morbidities such as maternal depression and anxiety, and increased stress during labor and delivery have been shown to affect lactation performance [14–16].

Although the exact mechanism by which psychosocial factors prevent successful breastfeeding is not understood, problems with frequent emptying and stimulation of the breast have suggested problems with the formation of tight junctions in the mammary alveolar epithelium. The formation of tight junctions normally prevents plasma-derived products, such as sodium, from exiting mammary alveolus. When the junctions are open, sodium concentrations increase in the lumen of the mammary alveolus, and therefore in the breast milk [35]. The literature reveals that a drop in BMS is highly predictive of successful lactation, successful post-partum maternal endocrine and behavioral adaptation, and effective mother-infant interaction [14,36].

However, we know little about the interrelation of prenatal attachment, maternal anxiety, successful breastfeeding, and BMS levels in pregnancies with regular follow-up at prenatal education class and baby friendly hospital. This connection between mothers and their unborn babies and other prenatal factors continue to have an effect in the birth and postnatal period. Maternal depression also influences the attachment of the newborn and may affect the child's development, leading to cognitive, social, emotional, and behavioral problems that last into adolescence. This study aimed to provide data that might resolve the relationship between prenatal attachment and BMS levels and other variables by investigating whether mother-infant attachment had an effect on BMS values.

## 2. Material and methods

This prospective case-control study was conducted at Baskent University and approved by the Institutional Review Board and Ethics Committee of Baskent University (project no: KA06-84). The study was a longitudinal survey in a sample of low-risk pregnant women recruited from prenatal education classes. Low-risk pregnancy was described as a pregnant woman who met the inclusion criteria: singleton pregnancy, uncomplicated obstetric history (no stillbirth, neonatal death, consecutive miscarriages, fetal death, preterm birth <32 weeks, isoimmunization, gestational diabetes), no current pregnancy complication (e.g. life threatening, or major fetal anomaly), no precluding medical conditions (no cardiac disease, hypertension, diabetes, epilepsy, severe asthma, substance use or addiction, significant psychiatric disorders, and body mass index (BMI) >35 or <17 kg/m$^2$ [28].

Mothers who were regularly followed at the obstetric outpatient clinic of Baskent University Hospital during their current pregnancy and attended breastfeeding classes during their third trimester were recruited for the study. The mothers were approached about the study just before the first session of the breastfeeding class and asked to participate. When they agreed, written informed consent was obtained and the Prenatal Attachment Inventory (PAI), State-Trait Anxiety Inventory 1 (STAI 1) and STAI 2 and plan data questionnaires were administered, and their demographics, medical histories, breastfeeding concerns were recorded. After the participants completed the PAI and the state anxiety and trait anxiety portions of the STAI, the mothers attended prenatal teaching classes.

The PAI was used to measure the attachment between the mothers and their unborn babies. The PAI was developed and revised by Müller based on 21 items, describing women's thoughts, feelings, and relationships to the fetus [3]. The response to each item is rated on a 4-point Likert scale: 4 = almost always, 3 = often, 2 = sometimes, and 1 = almost never. Examples of PAI items are 'I feel love for the baby,' 'I dream about the baby,' 'I know when the baby is asleep,' and 'I tell others what the baby does inside me.' Final scores were obtained by calculating the sum of the rating for the 21 items [Appendix 1]. The adaptation of the inventory to the Turkish population was performed by Duyan et al. [17].

Postnatal and prenatal maternal anxiety was assessed using the STAI, which was developed by Spielberger in 1970; the adaptation to the Turkish population has been performed [18,19]. The STAI is a self-test, having two main subscales assessing state and trait anxiety levels (STAI-I and II, respectively). Each subscale is composed of 20 items asking about the presence of anxious symptoms 'currently' and 'generally' [Appendix 2]. The state anxiety scale is designed to assess the level of relatively transient situation-related stress perceived in a particular situation. The trait anxiety scale is designed to measure the relatively stable long-term anxiety proneness in the individual. The scores from each scale increase with the severity of anxiety symptoms.

All of the mothers were encouraged to breastfeed their babies in a rooming-in nursing regimen, according to baby-friendly hospital initiative rules. The mothers and babies were invited for follow-up at hospital discharge. They were randomly assigned to be followed by one of the first two authors who had equal expertise and experience in well-child care lactation counseling and received continuous support as needed from each. All participants reported that they were planning to feed their babies only on breast milk for the first 6 months and the median planned breastfeeding duration was 12 (range, 6–24) months.

After delivery, the mothers and babies were followed up at regular intervals. Delivery mode, bodyweight of the 5th day, mother's anxiety state, STAI-1 scores, nipple problems including inverted, retracted or prominent nipples, BMS levels, and feeding behaviors were recorded. The same recordings were repeated on the 15th and 30th days. Breast-milk samples for sodium levels were collected with a breast pump from either breast on the postnatal 5th, 15th, and 30th days. Breast milk samples were collected at the first visit in the morning with a single pump session and whole breast expression so that sodium results were not affected by the diurnal variation of cortisol secretion. Breast milk samples were collected at the same time of day. After a single breast was completely expressed, 3 cc samples were taken and immediately transported to the laboratory. The milk sample was centrifuged at 3000 rpm for 10 min to separate the serum in which Na is present. Samples were stored at −20 °C until required for analysis. Sodium levels were analyzed using the ion-selective method in an Hitachi Modular Analytics ISE 1900 module. Based on the study of Koo and Gupta, breast milk sodium levels were categorized into two groups as normal and high [20]. According to the study of Koo and Gupta, breast milk with values of 16 mmol/L and above on the 5th day, 10 mmol/L and above on the 15th day, and 7 mmol/L and above on the 30th day were included in the high BMS group. Values below this were included in the normal BMS group.

Statistical analysis was performed using the SPSS v25 software package. The Chi-square and Mann–Whitney tests were used to compare sociodemographic and pregnancy characteristics. To evaluate the internal consistency of the PAI, Cronbach's Alpha coefficient was calculated. The Kolmogorov–Smirnov test was used to examine the distribution of PAI scores. The *t*-test was used to determine if PAI scores varied according to the marital status, parity, and planned pregnancies. Pearson's correlation and Spearmen's correlation coefficients were calculated in parametric and nonparametric assumptions, respectively, where appropriate. The Chi-square and *t*-test were used to evaluate potential group differences for categorical and continuous variables, respectively, for which *P*-values .05 were considered to be significant.

## 3. Results

During the study period, 50 patients met the inclusion criteria for the study. The mean age of the mothers and the mean gestational age were 29.6 ± 3.4 years and 38.4 ± 0.9 weeks, respectively. The mean birth weight of the babies was 3433 ± 385 g. Ten percent of the pregnancies were through in vitro fertilization (IVF), and the planned pregnancy rate was 66%. Most (90%) of the study group was primiparous, and 86% had no history of abortion. The majority (80%) of the group was university graduates and 70% were employed mothers, 8% of mothers were diagnosed as having depression, and 6% had medication that they used continuously. Also, 6% of the pregnant women were current smokers, and 2% were using alcohol. Just over half (56%) of the babies were born female.

Six percent of pregnant women had abnormalities detected in ultrasonography, which were minor abnormalities with non-life threatening. The mean STAI-1, STAI-2, and PAI scores were 38.2 ± 7.1, 38.8 ± 6.9, and 41.6 ± 10, respectively. When the study group was classified according to BMS levels, no difference was observed between the groups in terms of pregnancy STAI-1, pregnancy STAI-2, Muller PAI, and STAI-1 scores of the 5th, 15th, and 30th days (Supplemental Table 1). There were no differences between the groups regarding the mother's age, gestational age, and birth sex. The high BMS groups at the 15th and 30th days had a significantly higher birth weight ($p = .009$, $p = .045$, respectively). Also, the normal spontaneous vaginal delivery rate was higher in the normal BMS group on the 15th day but was not statistically significant ($p = .053$). Maternal education level and maternal occupation status did not differ between the three groups. We found no relation between BMS levels and pregnancy types, parity, abortus histories, and planned pregnancies (Table 1). Body weights of babies on the 5th day were significantly higher in the high BMS group both on the 15th day ($p = .002$) and the 30th day ($p = .023$), whereas the 15th day weights were found to be statistically significantly higher only on the 15th day in the high BMS group ($p = .004$) (Table 2). There were no significant differences between the groups according to the change in weight (Delta 5, Delta 15 and Delta 30) of the babies on the 5th, 15th, and 30th days. Nipple abnormalities, feeding type, and breastfeeding anxiety had no significant effect on BMS levels on the 5th, 15th, and 30th days (Table 2).

In the correlation analysis, there was no correlation between BMS levels on the 5th to 15th days and pregnancy STAI-1, Pregnancy STAI-2, Muller PAI, and STAI-1 scores of the 5th, 15th, and 30th day (Table 3). However, BMS levels on the 30th day had a positive significant correlation with STAI-1 scores on the 15th day ($r = 0.473$, $p = .006$). Additionally, STAI-1 scores on the 30th day showed a significant correlation with STAI-1 on the 5th day ($r = 0.416$, $p = .015$), STAI-1 on the 15th day ($r = 0.497$, $p = .003$), and BMS levels on the 30th day ($r = 0.615$, $p < .001$). The pregnancy STAI-1 score had a significant correlation with the STAI-1 score on the 5th day ($r = 0.345$, $p = .031$). We found a negative significant correlation between mother's age and pregnancy STAI-1 total scores ($r = -0.354$, $p = .012$). A negative correlation was found between the mother's educational status and pregnancy STAI-1 ($r = -0.323$, $p = .022$) and STAI-2 anxiety scores ($r = -0.397$, $p = .004$). As the mother's education level increased, the anxiety scores decreased. Also, there were negative correlations between planned pregnancies and pregnancy STAI-1 ($r = -0.325$, $p = .021$, planned pregnancies vs. unplanned pregnancies: 36.1 ± 4.9 vs. 42.1 ± 9.1; $p = .020$), STAI-2 ($r = -0.531$, $p < .001$, planned pregnancy vs. unplanned pregnancy: 36.1 ± 6.9 vs. 43.9 ± 5.8; $p < .001$) and STAI-1 scores on the 30th day ($r = -0.463$, $p = .004$, planned pregnancies vs. unplanned pregnancies: 34.1 ± 7 vs. 41.1 ± 6.5; $p = .017$). The study instrument was tested for evidence of reliability using the Cronbach's Alpha coefficient of internal consistency. The Cronbach's Alpha for the PAI was 0.903. The mean PAI values were 41.6 ± 10. The PAI score ranged from 21 to 59. Also, we found a positive correlation between PAI scores and the number of pregnancies ($r = 0.332$, $p = .018$) and a negative correlation with the birth week ($r = -0.331$, $p = .039$).

## 4. Discussion

Our results demonstrated that maternal-fetal attachment and anxiety, which can be evaluated with more objective scoring systems such as the STAI and PAI during pregnancy, had some postnatal effects on both the mothers and their babies. Mothers' psychological well-being, maternal-fetal attachment, and the effect on their babies should extend from the prenatal period to the postnatal period. This study showed that the effect of anxiety on the mother in the prenatal period continued to maintain in the postnatal period. Interestingly, positive effects related to the number of births on maternal-fetal bonding were observed. However, contrary to our expectations, no effect on BMS levels was observed. We found that the PAI scores decreased with each gestational week. This is the first study to evaluate the relationship between BMS levels and prenatal attachment.

The first milk formed in the mother, namely colostrum, is a compound that is poor in sodium, chloride and lactose, and has rich immunological properties [29–31]. Its content changes over time during the lactogenesis. With phase 2 of lactogenesis, the lactose content of breast milk increases and its sodium content decreases. The closure of tight connection regions in mammalian epithelial cells and the onset of the secretory phase cause these changes. The sodium content of breastmilk and the sodium-potassium ratio is accepted as an indicator of the secretory phase of lactogenesis [32]. The timing of secretory activation (lactogenesis stage II) varies among women. It has been shown that this phase is delayed, especially after delivery in obese women and preterm deliveries [33,34]. In a study that investigated the timing of stage 2 lactogenesis in primiparous women, the authors found that good antenatal metabolic control including higher serum insulin secretion

**Table 1**
Maternal characteristics according to the breast milk sodium level.

| | Breast milk Na level on 5th day | | | Breast milk Na level on 15th day | | | Breast milk Na level on 30th day | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal BMS | High BMS | P-value | Normal BMS | High BMS | P-value | Normal BMS | High BMS | P-value |
| Mother age, mean±SD | 29,3 ± 2,2 | 30,3 ± 3,1 | .463 | 28,7 ± 3,9 | 30,8 ± 2,8 | .127 | 28,6 ± 3,2 | 30,5 ± 3,1 | .333 |
| Birthweight, mean±SD eight, | 3394 ± 614 | 3412 ± 272 | .916 | 3155 ± 293 | 3519 ± 292 | **.009** | 3076 ± 364 | 3470 ± 305 | **.045** |
| Gestational age, median, (mean-max) | 38 (37–40) | 38 (38–40) | .708 | 38 (38–40) | 38 (37–40) | .417 | 38(38–38) | 38(37–40) | .349 |
| NSVD, n(%) | 3(50) | 6(21,4) | .306 | 4(57) | 4(16) | **.053** | 2(66) | 6(20) | ,147 |
| Sex, male;n(%) | 2(33) | 12(42) | 1 | 2(28) | 11(44) | .671 | 0 | 14(46.7) | .244 |
| Maternal education, University; n(%) | 5(83) | 25(89) | .559 | 7(100) | 22(88) | 1 | 3(100) | 26(86) | 1 |
| Maternal occupation, employee; n(%) | 4(66) | 24(85) | .354 | 5(71) | 20(80) | .684 | 2 (66) | 23(76) | .578 |
| Pregnancy type, IVF;n(%) | 1(16) | 3(10) | .559 | 1(14) | 1(4) | .395 | 1(33) | 2(6) | .256 |
| Smoking in pregnancy, n(%) | 0 | 1(3) | 1 | 0 | 2(8) | 1 | 0 | 2(7) | 1 |
| Primipar, n (%) | 6(100) | 26(93) | 1 | 7(100) | 22(88) | 1 | 3(100) | 27(90) | 1 |
| Abortus history; n(%) | 1(17) | 5(18) | 1 | 1(14) | 4(16) | 1 | 0 | 5(17) | 1 |
| Planned pregnancy;n(%) | 4(66) | 22(78) | .609 | 4(57) | 22(88) | .101 | 2(66) | 25(83) | .464 |

**Abbreviations:** SD: Standard deviation; NSVD: Normal spontaneous vaginal delivery; IVF: In-vitro fertilization; BMS: Breast milk sodium.

**Table 2**
Postnatal characteristics according to the breast milk sodium level.

| | Breast milk Na level on 5th day | | | Breast milk Na level on 15th day | | | Breast milk Na level on 30th day | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal BMS | High BMS | P-value | Normal BMS | High BMS | P-value | Normal BMS | High BMS | P-value |
| Weight on 5th day, mean±SD | 3358 ± 562 | 3321 ± 336 | .843 | 2997 ± 237 | 3450 ± 133 | **.002** | 2900 ± 156 | 3397 ± 349 | **.023** |
| Weight on 15th day, mean±SD | 3734 ± 603 | 3622 ± 315 | .549 | 3317 ± 249 | 3792 ± 379 | **.004** | 3270 ± 310 | 3730 ± 392 | .060 |
| Weight on 30th day, mean±SD | 4412 ± 771 | 4239 ± 332 | .648 | 4068 ± 307 | 4380 ± 411 | .074 | 3916 ± 471 | 4350 ± 387 | .077 |
| Delta[a] 5 mean±SD | −36 ± 150 | −98 ± 150 | .404 | −158 ± 186 | −58 ± 133 | .132 | −176 ± 277 | −72 ± 134 | .267 |
| Delta[a] 15 mean±SD | 340 ± 324 | 191 ± 207 | .208 | 161 ± 260 | 244 ± 221 | .418 | 196 ± 331 | 226 ± 223 | .834 |
| Delta[a] 30 mean±SD | 1018 ± 381 | 835 ± 255 | .198 | 912 ± 259 | 843 ± 293 | ,582 | 840 ± 266 | 863 ± 289 | .896 |
| Feeding type on 5th day, breastfeed; n (%) | 5(83) | 25(89) | .559 | 7(100) | 21(87) | 1 | 3(100) | 25(86) | 1 |
| Breastfeeding anxiety on 5th day; n (%) | 2(33) | 6(21) | .609 | 1(14) | 6(25) | 1 | 0 | 8(27) | .555 |
| Nipple abnormalities on 5th day; n (%) | 4(66) | 14(50) | .660 | 4(57) | 12(50) | 1 | 2(66) | 15(51) | 1 |
| Feeding type on 15th day, breastfeed n(%) | 5(83) | 21(87) | 1 | 7(100) | 21(84) | .552 | 3(100) | 25(83) | 1 |
| Breastfeeding anxiety on 15th day; n (%) | 1(17) | 4(17) | 1 | 1(14) | 4 (16) | 1 | 1(33) | 4(13) | .400 |
| Nipple abnormalities on 15th day; n (%) | 0 | 1(4) | 1 | 0 | 1(4) | 1 | 0 | 1(3) | 1 |
| Feeding type on 30th day, breastfeed; n (%) | 5(83) | 22(88) | 1 | 7(100) | 21(84) | .552 | 3(100) | 25(83) | 1 |
| Breastfeeding anxiety on 30th day; n (%) | 3(50) | 6(24) | .320 | 1(14) | 7(28) | .646 | 1(33) | 7(23) | 1 |
| Nipple abnormalities on 30th day; n (%) | 2(33) | 1(4) | .088 | 0 | 3(12) | 1 | 0 | 3(10) | 1 |

**Abbreviations:** SD: Standard deviation; BMS: Breast milk sodium.
[a] Delta refers to change in weight over time.

**Table 3**
Correlation table between breast milk sodium level and inventory scales.

| | Correlations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | BMS on 5th day | BMS on 15th day | BMS on 30th day | Pregnant STAI-1 scores | Pregnant STAI-2 scores | Muller PAI scores | STAI-1 scores on 5th day | STAI-1 scores on 15th day | STAI-1 scores on 30th day |
| BMS on 5th day | 1000 | | | | | | | | |
| P-value | | | | | | | | | |
| BMS on 15th day | 0234 | 1000 | | | | | | | |
| P-value | 0,222 | | | | | | | | |
| BMS on 30th day | −0,160 | 0,161 | 1,000 | | | | | | |
| P-value | 0399 | 0378 | | | | | | | |
| Pregnant STAI-1 scores | −0094 | −0108 | 0006 | 1000 | | | | | |
| P-value | 0597 | 0556 | 0974 | | | | | | |
| Pregnant STAI-2 scores | −0257 | −0031 | −0110 | **745**[b] | 1000 | | | | |
| P-value | 0142 | 0866 | 0542 | **0000** | | | | | |
| Muller PAI Scores | 0112 | −0078 | 0235 | −0034 | −0004 | 1000 | | | |
| P-value | 0527 | 0670 | 0188 | 0817 | 0981 | | | | |
| STAI-1 scores on 5th day | −0025 | 0005 | 0226 | **345**[a] | 0,292 | 0123 | 1000 | | |
| P-value | 0889 | 0979 | 0213 | **0031** | 0071 | 0457 | | | |
| STAI-1 scores on 15th day | −0077 | −0145 | **473**[b] | 0255 | 0300 | 0138 | 0178 | 1000 | |
| P-value | 0690 | 0429 | **0006** | 0153 | 0090 | 0444 | 0328 | | |
| STAI-1 scores on 30th day | −0241 | −0001 | **615**[b] | 0220 | 0230 | 0091 | **416**[a] | **497**[b] | 1,000 |
| P-value | 0192 | 0996 | **0000** | 0198 | 0178 | 0598 | **0015** | **0003** | |

**Abbreviations:** BMS: breast milk sodium, STAI: State and Trait Anxiety, PAI: Prenatal Attachment Inventory.
[a] Correlation is significant at the 0.05 level (2-tailed).
[b] Correlation is significant at the 0.01 level (2-tailed).

relative to serum glucose after a glucose challenge and higher serum adiponectin level were associated with earlier onset of lactogenesis [34]. In these and similar studies on the onset of lactogenesis (such as maternal obesity), the main focus is on serum glucose. In our study, the main reason why we found no association between BMS and both maternal-infant bonding and anxiety levels seem to be related to the fact that the selected participants consisted of obstetrically low-risk pregnant women, who were well-educated, and had easy contact with their physicians in the postpartum period, they were mostly planned pregnancies in women with good socioeconomic status, accordingly, this was a very healthy population with low socioeconomic status risk factors, so at lower risk of lactation challenges than the population as a whole.

Some recent studies are suggesting that there is a relationship between depression and anxiety during pregnancy and maternal-fetal attachment [21]. Hart and McMahon found that women characterized as having low quality of fetal attachment reported significantly higher levels of anxiety and depression. In our study, we found no correlation between prenatal attachment scores and pregnancy STAI-1 and 2 scores and postnatal STAI scores. This result may be related to the small sample size or the patients not showing homogeneous distribution. In a study by Lindgren et al., who investigated the relationship between maternal-fetal attachment, prenatal depression, and health practice while considering pregnancy risk status, ethnicity, income, geographic region, and marital status, the authors found that low depression scores had higher maternal fetal attachment levels [22].

In a recent study that investigated the relationship between BMS values and postpartum anxiety and depression, Demirgören et al. found that BMS values were significantly higher in mothers with high anxiety scores [27]. Although the authors concluded that the high sodium content in breast milk was an indicator of lactation failure, it is questionable whether all babies were exclusively breastfed and there was no weight difference between the groups. In addition, Demirgoren et al. took measurements of maternal BMS from the mother's breastmilk at an average of 10 days postpartum (range, 8–15 days), and values above 18 mmol/L were considered to be high and the study was designed accordingly. We took the different reference values of BMS levels according to the reference age with term infants based on Koo and Gupta's study. Contrary to this study, we found no differences between the groups in terms of STAI scores. However, in our study, we found that state anxiety and trait anxiety scores during pregnancy correlated positively with anxiety scores in the postnatal period. We think that these findings are related to the inability to correct the environmental and social factors that cause anxiety in the short term and continue the existing state of anxiety.

The effect of gestational age on prenatal attachment has mainly been studied with specific populations. Generalizability may therefore be limited, but the finding that prenatal attachment increases throughout gestation is repeatedly reported [23,24]. In our study, it was observed that as the week of gestation increased, the prenatal attachment scores decreased. This result, which was contrary to what was expected, may be related to the investigation of mothers with pregnancies as early as 20–24 gestational weeks in many studies. In our study group, the youngest pregnancy was 36 weeks. The gestational weeks of the participants were in a narrow range. The scores may have been low because the mothers were in gestational weeks close to term when their babies could be born safely.

The study by Koo and Gupta, which was one of the first studies on BMS values in various gestational weeks, found that sodium levels were high after birth and gradually decreased [20]. Similarly, we observed decreasing BMS levels on the 5th, 15th, and 30th days. In the study conducted by Tarcan et al., which investigated neonatal jaundice in babies with weight loss and hypernatremia, the authors found that BMS levels increased during the postnatal period, especially in the group with weight loss of more than 10% on the admission day to the hospital and in those with hypernatremia [25]. In another study by Özbek et al., who investigated the maternal psychosocial aspect in hypernatremic dehydrated babies with high BMS levels, they found that mothers with high BMS levels had a poor perception of themselves as a mother, higher rates of unplanned pregnancies, and higher rates of having previous psychological morbidity [26]. Similar to their study, we found no difference in BMS values in terms of maternal education and work status, but in our study, unlike their study, we observed no difference in terms of planned pregnancies. In the same study, STAI-1 scores were found to be significantly higher in the group with high BMS values compared with the control group but found no difference in STAI-2 scores. In our study, we observed no difference between the groups in STAI scores during pregnancy and in the postpartum period. We interpreted this difference as bias due to the more serious illness of individuals with high sodium values; these participants were more likely to be anxious. Our study group consisted of babies who were cared for by the mother and had no serious problems. Özbek et al. found that BMS values were higher in the group with hypernatremia with excessive weight loss at the time of admission to the hospital compared with the control group, and Tarcan et al. found that BMS values were higher in the group with the most severe dehydration and hypernatremia with weight loss over 10%.

In studies that investigated the association between prenatal attachment, depression, and anxiety, there are some conflicting results. In a recent metanalysis, groups of patients were found to be highly heterogeneous, especially in high-risk pregnancies, with a negative correlation between prenatal attachment and depression [37]. Although we did not evaluate mothers' depression conditions using scales, it was thought that they were less likely to have depression because they were low-risk pregnancies in well-educated women from a high socioeconomic environment. As a result, we may not have found differences in milk sodium content due to similar levels of bio hormonal mechanisms, e.g., cortisol, prolactin or a similar level of psychosocial status, which affects tight connection regions in the mammary gland epithelium. In another study that investigated possible sociodemographic and clinical factors affecting maternal-fetal attachment (personality traits, styles used to deal with stress, levels of depression and situational anxiety, and marital status), similar to our study, the authors found no correlation between prenatal attachment and anxiety [38]. We speculate that this result, which is similar to ours, was because anxiety and maternal-fetal attachment may have affected the different neurohumoral mechanisms in the body compartment.

Our study has several limitations. First, the subjects of our sample were only low-risk pregnant women who were recruited from prenatal education classes. Most of them were primiparous, married, with middle-to-high social and education levels, and likely to be motivated towards anything concerning the baby's wellbeing and prenatal care. Consequently, our results cannot be generalized because factor analysis results can be sample-related and can be differentiated from one nation to another due to sociodemographic differentiations. Results could be different in groups with different characteristics. One of the strengths of the study is that it is the first to investigate the relationship between mother-infant attachment and BMS, which is associated with postnatal lactation. Although we found no significant relationship, we think that the result was related to the fact the study group comprised pregnant women with low risk and good relative socioeconomic status. We think that studies with larger sample sizes and a more heterogeneous group will provide different results.

To the best of our knowledge, this is the first study to show that there is no relationship between BMS levels and PAI scores in low-risk pregnancies with healthy babies. Further, larger sample-sized studies, including a more heterogeneous or specified group of pregnancies, are needed to understand the relationship between these interactions. Although there is no significant relationship between PAI scores and BMS values, we hope that psychosocial aspects that increase mother-infant attachment and approaches to support this will positively contribute to the postnatal adaptation and transition period.

## Author contributions

M. S wrote the manuscript. NŞ. V and GA conceptualized and designed the study. GA interpreted the results; edited and critically reviewed manuscript; MT: collaborated in data analysis and data collection. MS: performed the statistical analysis; All authors reviewed and approved the final draft of the manuscript.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.


## Acknowledgement

None.


## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cpnec.2021.100085.


## Funding

None.


## Ethical approval

This study was approved by the Institutional Review Board and Ethics Committee of Baskent University (project no: KA06-84).

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