Differences Between Exclusive Breastfeeders, Formula-Feeders, and Controls: A Study of Stress, Mood, and Endocrine Variables

Maureen W. Groër, PhD, RN, FAAN

The purpose of this study was to examine relationships among lactational status, naturalistic stress, mood, and levels of serum cortisol and prolactin and plasma adrenocorticotropic hormone (ACTH). Eighty-four exclusively breastfeeding, 99 exclusively formula-feeding, and 33 nonpostpartum healthy control women were studied. The postpartum mothers were studied cross-sectionally once between 4 and 6 weeks after the birth. Stress was measured using the Perceived Stress Scale, the Tennessee Postpartum Stress Scale, and the Inventory of Small Life Events. Mood was measured using the Profile of Mood States. Serum prolactin, plasma ACTH, and serum cortisol levels were measured by commercial ELISA (enzyme-linked immunosorbent assay) kits. Results indicate that breastfeeding mothers had more positive moods, reported more positive events, and perceived less stress than formula-feeders. Reports of stressful life events were generally equivalent in the two groups. Serum prolactin was inversely related to stress and mood in formula-feeders. When breast and formula-feeders were compared to controls, they had higher serum cortisol, lower stress, and lower anxiety. Breastfeeders had lower perceived stress than controls. Breastfeeders had lower depression and anger and more positive life events reported than formula-feeders. However, there were few correlations among stress, mood, and the hormones in postpartum mothers, and those only in formula-feeders, whereas strong relationships were found between serum ACTH and a number of stress and mood variables in controls. Postpartum mothers reported a range of stress and negative moods at 4 to 6 weeks, and in formula-feeders, serum prolactin was related to some of the stress and mood variables. Breastfeeding appears to be somewhat protective of negative moods and stress.

Key words: *postpartum, stress, mood, breastfeeding, endocrinology*

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The postpartum period is often a stressful and demanding time, but nature may protect mothers from excessive stress reactivity (Groer, Davis, & Hemphill 2002; Hill, Chatterton, & Aldag, 2003). In rats and many other mammals, lactation is characterized by a unique physiologic state directed toward protection of the maternal-infant dyad from extraneous and bothersome environmental stimuli. The physiologic changes at parturition and during lactation may be adaptive, reducing maternal reactivity to the environment, promoting calmness and nurturing behavior, maintaining quantity and quality of milk, enhancing immune function, and opposing glucocorticoid-mediated catabo-

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lism (Altemus, Deuster, Galliven, Carter, & Gold, 1995). Lactating rats have a tonically elevated glucocorticoid secretion but blunted adrenocorticotropic hormone (ACTH) following stressor exposure (Windle et al., 1997). Biological changes include decreased transcription of the corticotropin-releasing hormone (CRH) gene and decreased release of CRH, ACTH, cortisol, oxytocin, prolactin, and catecholamines in response to stressors. Behaviorally, dams are quieter and less aggressive and anxious and their exploratory behaviors are directed toward the pups (Shanks, Kusnecov, Pezzone, Berkun, & Rabin, 1997; Windle et al., 1997). Nevertheless, when ethologically significant stressors are introduced to lactating dams, especially when the pups are present and threatened or in danger, some studies show that the maternal hypothalamic-pituitary-adrenal (HPA) axis does respond appropriately (Deschamps, Woodside, & Walker, 2003).

The mechanism by which the stress response is attenuated is thought to be related to the hormones of lactation. Estrogen is an important factor in the secretion of ACTH. Estrogen-responsive elements have been identified on the promotor region of the CRH gene, with estrogen directly stimulating CRH production (Magiakou, Mastorakos, Webster, & Chrousos, 1997). Thus, the low levels of estrogen during lactation may suppress CRH release by the hypothalamic paraventricular nucleus. In addition, oxytocin and prolactin, the levels of which are high during lactation, may inhibit the HPA axis through actions within the brain and peripherally (Cook, 1997; Neumann, 2003; Torner & Neumann, 2002). Prolactin levels are higher in breastfeeders, and the hormone is known to be involved in maternal behavior that may alter stress responses.

Although there is considerable evidence that many lactating mammals exhibit markedly down-regulated adrenergic and HPA reactivity (da Costa, Wood, Ingram, & Lightman, 1996; Lightman, 1992), the studies in humans are scanty and equivocal. Comparison of lactating human mothers to other mammals is difficult because of the nature of nursing patterns. Humans may feed at specific scheduled hour intervals, may give mixed breast- and formula-feedings, may pump rather than actually suckle, or may feed totally ad lib. The latter approach is used by all other mammals. Controversy regarding the nature of stress hyporesponsiveness in human lactating mothers is related to whether the stress axes are less responsive only during the actual time of suckling, or whether there is a generally blunted basal neuroendocrine response to stress. Physical exercise on a treadmill was associated with decreased plasma ACTH, cortisol, and glucose in lactating compared to nonlactating women (Altemus et al., 1995). Lactating women had lower perceived stress scores and less negative moods compared to nonlactators (Mezzacappa & Katlin, 2002). However, laboratory stress paradigms using the Trier Social Stress Test have shown that lactating women did not have an attenuated HPA response when tested 40 min after feeding their infants compared to nonlactating postpartum women and controls (Altemus et al., 2001). A group of 10 women was followed during pregnancy and at 8 weeks postpartum and compared to a control group on stress responses to cold stress (Kammerer, Adams, von Castelberg, & Glover, 2002). The women did not show reactivity to the cold pressor challenge during late pregnancy, but reactivity was restored in the postpartum. However, lactational status was not recorded. In another experiment, lactating women were tested with the Trier Social Stress Test while either suckling or holding their infants. The suckling condition was associated with attenuated cortisol, ACTH, epinephrine, and norepinephrine release in response to the laboratory stressor in suckling women, but not in the holding condition (Heinrichs et al., 2001). The blunted stress response during human lactation may thus depend on the frequency of feeding and on the significance of the stressor. Another consideration that has not been addressed is the exclusivity of breastfeeding. We report the first study comparing exclusively breastfeeding, formula-feeding, and control women on naturalistic stress, mood, and endocrine differences and relationships.

An assumption was made that chronic severe stress would produce chronic activation of the HPA axis and lead to higher basal cortisol levels and dysregulation of the HPA axis in the women in this study. Clearly years of stress research suggest that reactivity to stressors may increase HPA activation with resulting increased serum cortisol. Nevertheless, the stress response is designed to be short term in nature, without long-term elevations in hormones of the HPA axis. Chronic stress effects on basal serum cortisol in humans are not so well described, but evidence does point toward basal cortisol elevation in some chronically stressed states. Best characterized is chronic depression, which results in chronically elevated CRH secretion, and resultant hypercortisolemia, often with loss of circadian rhythmicity. In addition, chronic stress is a major trigger for anxiety and mood disorders (Tafet & Bernadini, 2003). Chronically hyperactive HPA responses may lead to features of the metabolic syndrome, osteoporosis, atherosclerosis, and Th-1 immunosuppression (Tsigos & Chrousos, 2002). Other known conditions or situations studied by these investigators that result in a similar chronically activated HPA include anorexia nervosa, obsessive-compulsive disorder, panic anxiety, alcoholism, alcohol and narcotic withdrawal, excessive exercising, poorly controlled diabetes mellitus, hyperthyroidism, and childhood sexual abuse (Tsigos & Chrousos, 2002). Other stressors associated with persistent rather than intermittent activation of the HPA include chronic pain (Bomholt, Harbuz, Blackburn-Munro, & Blackburn-Munro, 2004), care giving (Bauer et al., 2000), social isolation in rats (Weiss, Pryce, Jongen-Relo, Nanz-Bahr, & Feldon, 2004), lack of social support (Turner-Cobb, Sephton, Koopman, Blake-Mortimer, & Spiegel, 2004), starvation (Girod & Brotman, 2004), noise (Ising & Braun, 2000), unemployment (Ockenfels, Smyth, Kirschbaum, Hellhammer, & Stone, 2004), work days compared to weekends (Schlotz, Hellhammer, Schultz, & Stone, 2003), and separation or divorce (Powell et al., 2000). There is also new evidence that there are inter-individual variations in basal glucocorticoid "tone," potentially influenced by HPA activity, peripheral glucocorticoid receptors, and increased peripheral cortisol regeneration (Girod & Brotman, 2004). Thus, it would seem to be a reasonable assumption that severe postpartum distress and dysphoric moods might impact the HPA axis and produce elevated basal cortisol levels.

Research Questions

The study attempted to answer the questions, "Is there an influence of lactational status on perceptions and reports of stress in postpartum mothers?" and "What are the relationships between stress, mood, and blood levels of prolactin, ACTH, and cortisol in lactating and nonlactating postpartum mothers compared to controls?" These questions are derived from a model of lactational stress resistance developed from the literature and research studies. It is presented in Figure 1.

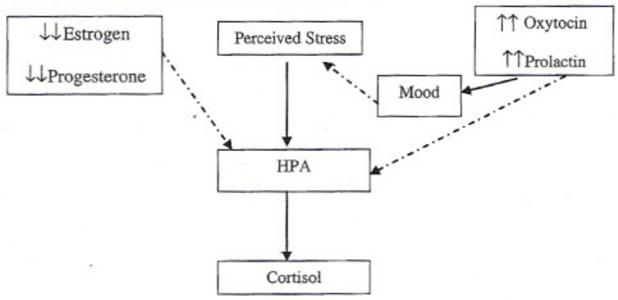

Figure 1. Lactational stress resistance model. Events during the postpartum period produce perceptions of stress and distressful moods that lead to activation of the hypothalamic-pituitary-adrenal (HPA) axis. Lactational stress resistance may buffer the physiological stress response. High levels of oxytocin and prolactin and low levels of estrogen and progesterone in breastfeeders may act through effects on mood and the hormones of the HPA to decrease this response. Dotted lines indicate inhibitory pathways.

Materials and Methods

Sample

Three hundred participants were recruited in the postpartum unit of a local hospital or in physician offices, and 183 completed the study. Exclusion criteria were age under 18 or over 45 years; serious complications during pregnancy, labor, and delivery; infants' morbidity; chronic mental or physical illnesses; and medications that influence immune function. Use of oral contraceptives or Depo-Provera was not an exclusion criterion. Mothers who had used any supplementation during the postpartum period were excluded from these analyses, so 99 formula-feeders (never breastfed) and 84 breastfeeders composed the two groups. Thirty-three control participants were undergraduate and graduate nursing student volunteers who completed the study instruments and provided a morning blood sample in the lab. Menstrual cycle stage was recorded, but the variables under study did not vary with cycle stage, so menstrual cycle was not controlled. Participation took place during an academic exam-free period. Exclusion criteria were current or chronic illness or pregnancy. The blood samples were analyzed in the same manner as those from postpartum mothers with the exception of serum prolactin.

Procedure

Institutional review boards approved the study, and all participants gave informed consent. Mothers were given a gift of $50 for participation. Mothers were sent study instruments before they were visited in homes 4 to 6 weeks postpartum. Registered nurse research assistants picked up questionnaires and collected a venipuncture of 10 ml blood. Breastfeeding mothers were asked to feed their infants as usual, and blood was collected 1 to 3 hr after this a.m. feeding. All samples were collected during the morning hours, between 8 and 11 a.m., and immediately brought to the lab. Breastfeeders were required to be exclusively breastfeeding and not pumping milk, and if it was discovered at testing that they supplemented at any time during the postpartum period, they were dropped from analysis.

Instruments

The instruments were chosen based on their ability to quantify stressful life events since the baby was born, particular postpartum stressors, perception of stress both at the time of testing and during the period since the baby was born, and a range of dysphoric moods that postpartum mothers often experience.

Perceived Stress Scale (PSS)

The PSS (Cohen, Kamarck, & Mermelstein, 1983) is a 14-item scale that assesses cognitions and emotions related to perceived general stress. The items indicate the degree to which respondents find their lives unpredictable, uncontrollable, and overloading—adjectives thought to be central components of the stress experience. There is a 5-point Likert-type scale response format with options ranging from *never* (0) to *very often* (4), and the scale has a range of 0 to 56. The scale was used in two ways in this study. One version of the scale inventoried stress perceptions since the baby was born, and the other version asked for "right now" perceptions.

Tennessee Postpartum Scale (TPS)

The investigators developed the TPS to tap unique postpartum stressors. The instrument was initially developed based on data from Horowitz and Damato (1999), who did a triangulated study of 95 postpartum women at Week 6. The TPS was given to 75 postpartum women, and changes were made based on their feedback. It now consists of 20 items on a 5-point Likert-type scale and has an alpha coefficient of .87 in the sample reported here. Factor analysis on 200 postpartum mothers, using principal components analysis with varimax rotation, showed that a four-factor solution accounted for 54% of the variance. The four factors identified appear to be related to managing one's life, worrying about the future, identity, and relationships.

Inventory of Small Life Events (ISLE)

The ISLE inventories minor, daily, negative, and positive events in a person's relationships with friends, spouses, and family. According to Zautra (1996), chronic stress is produced by exposure to everyday small, recurrent, uncontrollable, and unwanted life events. This is stress within the natural occurrences of everyday life, or "naturalistic" stress. The scale used in the research reported here is a modification of his scale, developed in collaboration with Zautra. It lists 77 events, and participants indicate how many times they have experienced each event since the baby was born. The three subscales focus on relationships (family, friends, and spouse). It is scored by adding the number of times each event was experienced.

Profile of Mood States (POMS)

The POMS (McNair, Lorr, & Droppleman, 1992) is a 65-item instrument designed to elicit reporting of feelings during the past week, including the day of measurement. There are six subscales: tension-anxiety, depression-dejection, anger-hostility, vigor-activity, fatigue-inertia, and confusion-bewilderment. Experience of mood is reported on a 5-point Likert-type scale, with responses ranging from 0 (*not at all*) to 4 (*extremely*). The POMS was deemed ideal for assessing the whole range of moods in the postpartum.

All instruments were translated into Spanish for use by non-English-speaking participants, but only 2 participants required these translated instruments.

Biological Variables

Blood was collected in serum separator and heparinized collection tubes. Samples were placed on ice and transported to the lab within 2 hr of collection. Samples were centrifuged, aliquoted, and frozen at –20°C. ELISAs (enzyme-linked immunosorbent assays) were run in batches for prolactin, cortisol, and ACTH. Serum prolactin was analyzed by ELISA (Hope labs, Belmont, CA). Serum cortisol and plasma ACTH were measured by ELISA (DRG, Germany). The interassay and intra-assay coefficients of variation were less than 10% for all assays in our lab. Immune variables were also measured, but these are reported elsewhere (Groer, 2005). Cortisol and prolactin were measured in ng/ml and ACTH in pg/ml.

Statistical Methods

Descriptive statistics were computed on all numeric variables, with examination for skewness and outliers. Data were log 10 transformed if necessary to achieve normality. ACTH and prolactin required transformation. A p value of .05 was accepted as statistically significant because this study was exploratory, although the risk of a Type 1 error is acknowledged to be increased by the multiple comparisons done. To examine relationships among the variables of interest, Pearson product moment correlations were computed. To compare breast- to formula-feeders, t tests were employed, and to compare the three groups, one-way ANOVAS were used. ANCOVA was used to test the influence of demographic covariates on breastfeeder compared to formula-feeder differences on stress and mood.

Results

Sample

Data were collected on 183 mothers of whom 84 were exclusive breastfeeders and 99 were formula-feeders. Mean age was 25.3 ± 5.4 years, parity 1.87 ± 1.08, income \$28,000 ± \$16,000, 64% were married, and 22% worked full-time at the time of data collection. Racial distribution was 84% Caucasian, 7.5% Black, 5% Hispanic, and 1.7% Asian. Mean time of data collection was 4.6 weeks postpartum (range, 4 to 6 weeks). Statistically significant demographic differences between breast- and formula-feeders were as follows: breastfeeders were older, had higher income, fewer smoked, and more were married. There were no differences in weeks postpartum, type of delivery, labor length, number of minor delivery complications, number of physician visits, current body mass index (BMI), number of children, exercise patterns, race, and number of hours worked per week.

The student control group's mean age was 23.8 years, they were all Caucasian, income was \$28,000, they exercised 2.3 hr per week, they had no children, all but 3 were single, and they worked only 3 hr per week. Comparisons of the demographic data are presented in Table 1. There were no differences in incidence of breastfeeding versus formula by parity.

Differences Between Breastfeeders and Formula-Feeders

Figures 2, 3, and 4 display the breast- compared to formula-feeders on the stress scales. Perceived stress scores were at a higher mean than other adult female sample scores reported in the literature (mean PSS: 24.9, range 5 to 56). Both perceived stress "since the baby was born" and perceived stress "right now" were higher in the formula feeders ($t = -1.8, p = .05; t = -2.4, p = .016$; Figure 2). Reports of daily negative events were equivalent in the groups, but daily positive events on the ISLE were higher for breastfeeders ($t = 2.79, p = .007$; Figure 3). The "friends" negative events reports were significantly higher in formula-feeders ($t = 2.37, p = .02$). Postpartum stress was not significantly different between the breast- and formula-feeders (Figure 4). However, when the factor subscales identified by factor analysis of the TPS were analyzed, the managing and relationships subscales were significantly higher for breastfeeders, indicating that they perceived more stressful events in these areas. Mood scores were significantly different with lower depression ($t = 2.89, p = .004$; Figure 5), anger ($t = 2.59, p = .01$; Figure 6), and anxiety ($t = 2.7, p = .008$; Figure 7) scores in breastfeeders compared to formula-feeders. We have

Table 1. Demographic Descriptions of the Three Groups

Feeding	Age (years)	Income ($)	% Working	Marital Status	Weight (lbs)	Number of Cigarettes/Day
Breastfeeders	28.9	35,000	31	18% single, 81% married, 1% other	165	0.9
Formula-feeders	23.4	22,000	26	40% single, 56% married, 4% other	178	2.9
Controls	23.8	28,000	66	91% single, 9% married	136	0

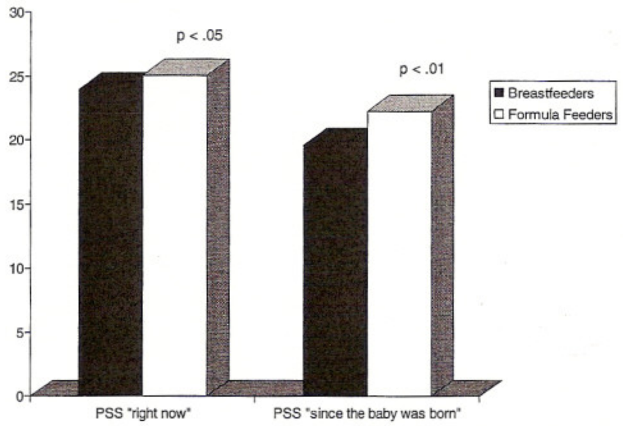

Figure 2. Perceived stress. Perceived stress scores "today" and perceived stress "since the baby was born" are significantly lower in breastfeeders compared to formula-feeders.
NOTE: PSS = Perceived Stress Scale.

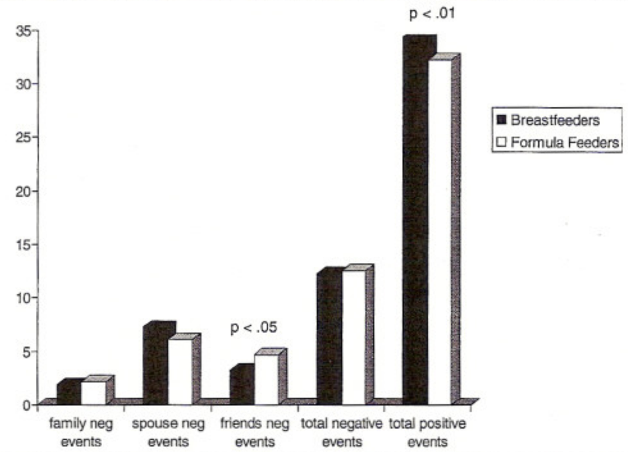

Figure 3. Small life events. Breastfeeders report as many negative small hassles and events with family, friends, and relations as do formula-feeders, but breastfeeders report significantly more positive daily events.

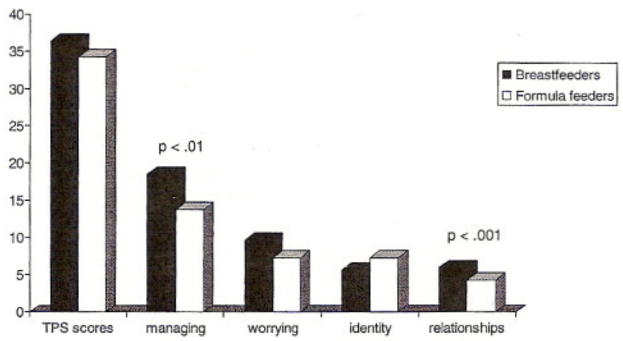

Figure 4. Postpartum stress. Breastfeeders report more stressful events related to managing one's life and relationships compared to formula-feeders.
NOTE: TPS = Tennessee Postpartum Scale.

reported on the stress-immune relationships of anger in this population (Groer & Thomas, 2005).

Serum levels of cortisol and ACTH were not significantly different between breast- and formula-feeders. Serum prolactin was, of course, significantly higher in the breastfeeders ($t = 7.58$, $p = .000$). Correlations between serum prolactin and several of the stress and mood variables were found in the postpartum mothers. Prolactin was not measured in controls. When the postpartum mothers were divided into breast- and formula-feeders, these correlations were observed only in the formula-feeding mothers. Total negative events on the ISLE were negatively correlated with prolactin ($r = -.34$, $p = .001$), as were anger ($r = -.23$, $p = .037$) and confusion ($r = -.204$, $p = .05$). ACTH and cortisol were not related to mood, negative life events, or postpartum stress, except for a relationship between ACTH and anxiety ($r = .2$, $p = .04$) and TPS and serum cortisol ($r = .23$, $p = .04$) in formula-feeders only. Serum cortisol was correlated with ACTH ($r = .27$, $p = .01$), again only in formula-feeders. We also found that primiparae had higher cortisol than multiparous mothers ($t = 2.29$, $p = .02$), but they did not differ in prolactin or ACTH, nor on mood or stress, except for negative life events, which were higher in primiparae ($t = 2.8$, $p = .005$).

The highest and lowest deciles on the stress and mood scores in postpartum mothers were compared for levels of cortisol, ACTH, and prolactin. Cortisol and ACTH were not statistically significantly different when the deciles were compared using traditional parametric statistics (t tests). However, because the variances were not equal, a Bayesian analysis, using the Behrens-Fisher distribution, found that the odds of higher cortisol in the highest depression decile were greater than 6:1. In the case of prolactin, there were statistically significantly different levels between the highest and lowest deciles for depression ($p = .03$), anxiety ($p = .01$), anger ($p = .000$), and total mood disturbance ($p = .003$), with the highest deciles having the lowest levels of prolactin. In these cases, prolactin is at least partly a proxy for breastfeeding.

There were also demographic relationships with serum prolactin. Correlations were present between prolactin and age ($r = .38$, $p = .000$), BMI ($r = -.175$, $p = .028$), income ($r = .402$, $p = .000$), and number of cigarettes smoked per day ($r = -.29$, $p = .000$). These variables are again all related to lactational status.

Analyses of covariance were performed on mood scores on the POMS, with income, marital status, and age, the three demographics that were significantly different between breast- and formula-feeders, entered as covariates, comparing breast- and formula-feeders. Marital status and age were not related to moods, but income was related to depression and anxiety. The covariate income was significantly related to depression, $F(1, 166) = 6.6$, $p < .01$, $r = -.25$. There was not an effect of feeding when income was controlled, $F(2, 166) = 1.8$, $p = .18$. For anxiety, the covariate income was also related, $F(1, 166) = 5.42$, $p = .02$, $r = -.2$, but when income was controlled, feeding remained related, $F(2, 166) = 3.88$, $p < .05$. These analyses also showed that only a small amount of variance in the psychosocial variables is explained by feeding status and income. If the participants with yearly income less than $10,000 are removed from analysis, income no longer predicts depression or anxiety, so the very poor mothers are skewing the analysis. Of the 48 mothers with this low income level, only 10 were breastfeeders.

Differences Between Postpartum Women and Controls

From these data, it would appear that there are differences in naturalistic stress perceptions and experiences in breastfeeders compared to formula-feeders, but in terms of HPA activity, the differences between them are small, and there are few stress hormone relationships to stressors and negative moods. Mood is clearly less negative in breastfeeders compared to both formula-feeders and controls (Figures 5, 6, and 7). If the two groups of postpartum women are combined and compared to the control group of nonpostpartum women on whom we have collected equivalent data (except for serum prolactin), several observations can be made (see Figure 8).

One-way ANOVAs were performed on the stress, mood, and hormonal variables, with the groups being breastfeeders, formula-feeders, and controls. Table 2 indicates those relationships, which are significant. Post hoc analysis (Tukey's HSD) was performed. For cortisol, the sources of variation were between formula-feeders and controls ($p = .01$) and breastfeeders and controls ($p = .02$). For perceived stress since the baby was born (or during the last month for controls), the source of variation was between breastfeeders and formula-feeders ($p = .05$). For perceived stress today, the difference was between breastfeeders and controls ($p = .03$). For total positive events, the variation was between breastfeeders and formula-feeders ($p = .002$). For postpartum stress scores, breastfeeders ($p = .008$) and formula-feeders ($p = .03$) were different than controls. The variation in depression was accounted for by the difference between breastfeeders and formula-feeders ($p = .011$). For anxiety, this was also true ($p = .01$), as well as a difference between breastfeeders and controls ($p = .002$). For anger, the variation was between breastfeeders and formula-feeders ($p = .01$).

Discussion

At the time of measurement, there was significant stress being perceived by the postpartum mothers as a

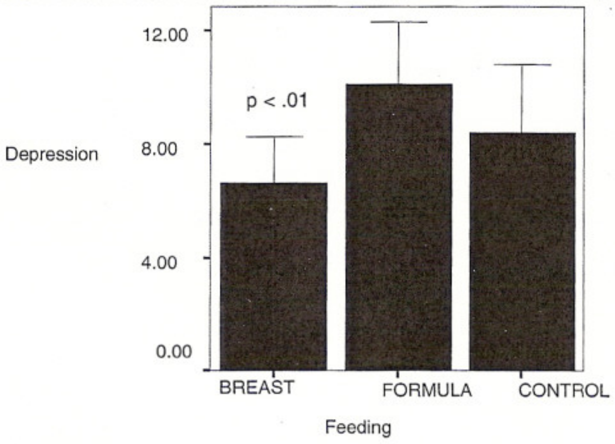

Figure 5. Comparison of depression scores. Breastfeeders had significantly lower depression scores on the Profile of Mood States instrument compared to both formula-feeders and controls.

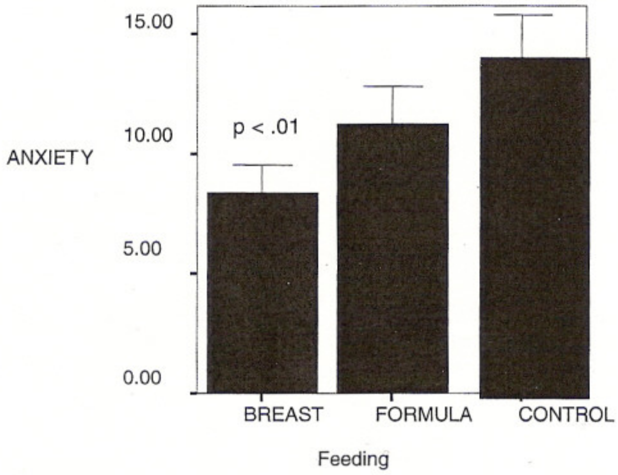

Figure 7. Comparison of anxiety scores. Breastfeeders had significantly lower anxiety scores on the Profile of Mood States instrument compared to formula-feeders and controls.

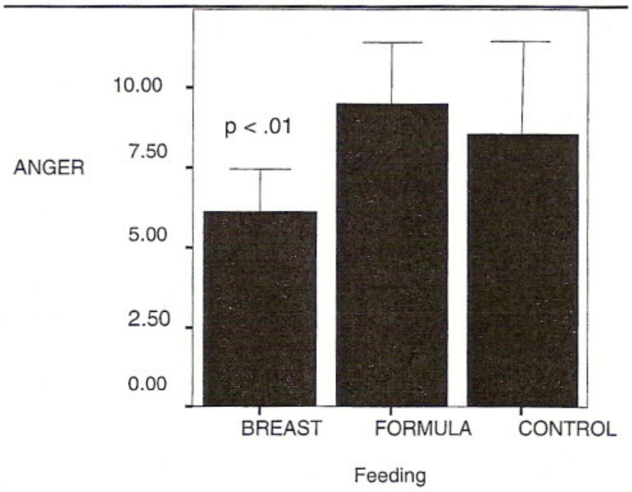

Figure 6. Comparison of anger scores. Breastfeeders had significantly lower anger scores on the Profile of Mood States instrument compared to formula-feeders and controls.

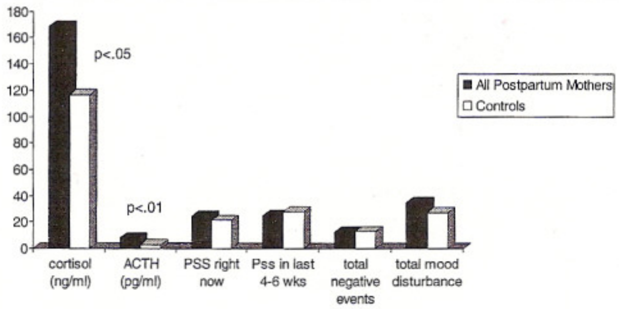

Figure 8. Postpartum women compared to controls. Compared to controls, postpartum mothers have higher serum cortisol and adrenocorticotropic hormone (ACTH) concentrations but are not different in terms of perceived stress, negative mood, and negative life events.
NOTE: PSS = Perceived Stress Scale.

whole, although the control group (mostly nursing students) also reported higher perceived stress scores than the published normative sample. The time of collection mirrors a time during which postpartum depression is most likely to appear, the first 4 weeks postpartum, with the highest depression scores occurring at 2 months postpartum (Goodman, 2004). It is also a time when mothers are dealing with returning to work, family support systems are leaving, and the honeymoon period after the birth is finished. Nevertheless, dysphoric moods are not exceptionally high compared to the normative sample or to the control group. The lactational status per se does not appear to make a major difference in stress perception or endocrine responses at the time of measurement. In relationship to animal studies, which have demonstrated a marked stress hyporesponsiveness in lactating dams (Shanks et al., 1997; Windle et al., 1997), it would seem that the naturalistic stress of daily negative

Table 2. Tests of Between-Subjects Effects for Depression and Anxiety, Controlling for Income

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Significance	Partial Eta Squared
Dependent Variable: Depression						
Corrected model	1,207.188[a]	2	603.594	6.644	.002	.074
Intercept	5,072.778	1	5,072.778	55.837	.000	.252
Income	601.748	1	601.748	6.624	.011	.038
Feeding	163.411	1	163.411	1.799	.182	.011
Error	15,081.048	166	90.850			
Total	28,524.000	169				
Corrected total	16,288.237	168				
Dependent Variable: Anxiety						
Corrected model	664.971[b]	2	332.486	7.714	.001	.086
Intercept	5,073.531	1	5,073.531	117.704	.000	.416
Income	233.637	1	233.637	5.420	.02	.032
Feeding	167.300	1	167.300	3.881	.05	.023
Error	7,112.172	165	43.104			
Total	24,338.000	168				
Corrected total	7,777.143	167				

a. $R^2 = .074$ (Adjusted $R^2 = .063$).
b. $R^2 = .086$ (Adjusted $R^2 = .074$).

events, specific postpartum stressors, and perceived stress are not markedly different in breastfeeders compared to formula-feeders. Mood is more positive, as is perception of positive life events, in breastfeeders. Stress hormones are higher than controls in postpartum mothers as a group, suggesting that their HPA axis is differentially regulated. Others have also found that cortisol is higher than controls in postpartum women (Kammerer et al., 2002). During the postpartum period, the HPA axis gradually recovers from its activated state during pregnancy, a process that takes about 12 weeks (Mastorakos & Ilias, 2003). During this time, there is possibly a refractoriness of cortisol feedback in the brain at the CRH neuron as a result of previous exposure to high levels of cortisol during the last trimester of pregnancy, and because of concurrent estrogen deficiency (Chrousos, Torpy, & Gold, 1998). These authorities point out that despite this refractoriness, total plasma cortisol levels were higher in 17 postpartum women they studied through the 12th postpartum week compared to controls (Magiakou et al., 1996). They suggested that this was related to elevated cortisol-binding globulin concentrations, which may be increased through the third postpartum month, and to adrenal gland hypertrophy and hyperresponsiveness to ACTH due to increased function during the last trimester. Perhaps postpartum mothers as a whole, regardless of lactational status, may be more comparable to lactating rats, which have a tonically elevated glucocorticoid level but lack CRH responsiveness in the pituitary. Unlike our data, Magiakou et al. (1996) did not see elevated ACTH as well. The higher cortisol levels in postpartum women that we observed may be due to increased cortisol-binding globulin or adrenal hypertrophy. On the other hand, the lack of strong relationships between stress hormones and stress and negative moods in the postpartum mothers might be explained by refractoriness of the HPA. Our findings of relationships when comparing lowest to highest deciles might indicate that stress, mood, and endocrine relationships are measurable in the extreme cases.

In animal experiments, the controls for lactating rats have typically been virgin controls, because postpartum bottle-feeding rats just don't exist. The altered HPA that has been attributed exclusively to lactational status in animal models, and lactational hormones, may rather relate to aspects of maternal nurturance physiology, regardless of lactation. Prolactin's relationship to stress and mood regardless of lactational status deserves attention, although the effects that we measured were generally small to moderate in size. Prolactin is involved in a host of maternal (and paternal) behaviors besides lactation, but its role in nonbreastfeeding postpartum women is unknown. Prolactin has long been known to be a stress hormone, rising in stress states (Noel, Suh, Stone, & Frantz, 1972). However, in mothers and fathers of several species, including humans, prolactin appears to affect parenting and caregiving behavior (Byrnes, Rigero, & Bridges, 2003; Fleming, Corter, Stallings, & Steiner, 2002; Schradin, Reeder, Mendoza, & Anzenberger, 2003). The presence of the infant(s) appears to be the most significant signal for prolactin production associated with caregiving. Although lower, prolactin in serum (and presumably brain and other sites) in postpartum nonlactating mothers may still have some function related to maternal behavior, as it was the formula-feeders who showed the stress, mood, and prolactin relationships.

The implications for nursing relate to the attention nurses need to give to postpartum mothers and their infants, the need to encourage breastfeeding, support nurturant behavior, and teach mothers to recognize and manage their stress. These data indicate that mothers need holistic health care through the early puerperium that focuses on both physical and emotional health.

Limitations

The study was cross sectional, and many potentially important variables were not measured or could not be controlled. A longitudinal study of these variables would provide helpful information about the neuroendocrinology of the postpartum. The repertoire of maternal behaviors seems to be an important factor to measure, and an assessment of the environment in which the testing took place would give a better picture of the maternal-infant relationship. The time of last feeding is another variable, as the half-life of prolactin is 10 to 25 min (Foye, Lemke, & Williams, 1995), and thus time introduces an important influence on prolactin levels. We could not ethically dictate when the mother should feed her baby for the purposes of the study. Maternal attachment in both breast- and formula-feeders is another variable that may influence prolactin and stress responsiveness.

Stress hormones measured in the serum may not give a picture of what is happening in the brain, especially in terms of CRH release, which is the primary level for lactation-associated refractoriness in the rat (da Costa et al., 1996). Furthermore, although we collected data at least 1 hr after awakening, between 8 and 11 a.m., we could not control time of collection more closely than this and we did not record actual time of venipuncture. Although data from both breastfeeders and formula-feeders were collected in the same way, it would be more precise to be able to covary time of collection in the analyses.

As with all studies comparing breast- and formula-feeding mothers, it is, in the United States, nearly impossible to find equivalency of socioeconomic status (SES). We made an effort to recruit lower SES breastfeeders and had success as evidenced by the fairly low mean income of our sample. Nevertheless, breastfeeders had some SES advantage (age, income, marital status) in our study, and these advantages translate in real life into stress buffering. Depression, in particular, in breast- compared to formula-feeders, appeared to be influenced by income, with the highest levels of depression appearing in the poorest mothers, and these are typically mothers who do not breastfeed.

Summary

The study provides a new look at stress and mood in the postpartum, with findings that suggest that exclusive breastfeeding is associated with more positive moods and less perceived stress, but low income is another very powerful influence on these variables. Unfortunately, low-income women often choose not to breastfeed. Compared to controls, postpartum women have higher levels of ACTH and cortisol, which may reflect incomplete recovery from the hypercortisolemia of the third trimester of pregnancy. There are few general correlations between stress, mood, and stress hormones, except when comparing extremes of mood and stress in the postpartum. This is in contrast to controls who do show stress-mood-ACTH relationships. Prolactin appears to be related to stress and mood in formula-feeding mothers.

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