



Analysis of cortisol levels in breast milk and blood serum in women with symptoms of postpartum depression

Analiza poziomu kortyzolu w mleku kobiecym i surowicy krwi u kobiet z symptomami depresji poporodowej

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Abstract

Introduction and Objective. Scientific studies report that the risk of symptoms of postpartum depression (PPD) can significantly reduce breastfeeding time. It has not yet been shown whether there is a difference in cortisol levels in breast milk and serum cortisol levels in women at risk of PPD but without symptoms. The aim of the study was assessment of the levels of cortisol in breast milk and levels of serum cortisol in women at risk of PPD four weeks after birth.

Materials and method. The study included 75 women who were recruited at a University Hospital and via social media. The proper study was conducted in the fourth week after delivery. The research tool used was The Edinburgh Postnatal Depression Scale (EPDS). Assessment of cortisol levels in breast milk was performed with the enzyme-linked immunosorbent assay CORTISOL saliva ELISA DiaMetra. Blood analysis was conducted in an ALAB Laboratory, one of a nationwide network of specialis laboratories.

Results. The prevalence of the risk of PPD symptoms in the study sample was estimated at 28% in EPDS. The risk of PPD symptoms does not differentiate between cortisol levels in breast milk and serum cortisol levels ($p > 0.05$). A correlation was shown between the level of cortisol in breast milk and in the blood serum of the study sample ($p < 0.03$).

Conclusions. The study indicates that the risk of PPD symptoms does not differentiate between serum cortisol levels and cortisol levels in breast milk. The level of cortisol in breast milk reflects the level of cortisol in the blood serum of the subjects.

Key words

postpartum depression, breastfeeding, Edinburgh Postpartum Depression Scale, milk cortisol, serum cortisol concentration

Streszczenie

Wprowadzenie i cel pracy. Badania naukowe donoszą, że występowanie ryzyka objawów depresji poporodowej może znacznie skrócić czas karmienia piersią. Nie wykazano dotychczas, czy istnieje różnica w składzie mleka kobiecego i w stężeniu kortyzolu w surowicy krwi u kobiet z ryzykiem objawów depresji poporodowej i wolnych od takiego ryzyka. Celem pracy była ocena składu mleka kobiecego i stężenia kortyzolu w surowicy krwi u kobiet z ryzykiem występowania objawów depresji poporodowej cztery tygodnie po porodzie.

Materiał i metody. W badaniu wzięło udział 75 kobiet, które rekrutowano w szpitalu uniwersyteckim oraz poprzez media społecznościowe. Badanie właściwe zostało wykonane w 4. tygodniu po porodzie. Narzędziem badawczym wykorzystanym w pracy była Edynburska Skala Depresji Poporodowej (EPDS). Ocenę poziomu kortyzolu w mleku kobiecym przeprowadzono za pomocą testu immunoenzymatycznego Cortisol Saliva ELISA DiaMetra. Analizę krwi wykonano w ogólnopolskiej sieci Laboratorium ALAB.

Wyniki. Częstość występowania ryzyka objawów PPD w badanej próbie została oszacowana w EPDS na 28%. Ryzyko występowania objawów PPD nie różnicuje poziomu stężenia kortyzolu w surowicy krwi i poziomu kortyzolu w mleku kobiecym ($p > 0,05$). Wykazano powiązanie pomiędzy poziomem kortyzolu w mleku matki i surowicy krwi badanych ($p < 0,03$).

Wnioski. Badanie to sugeruje, że ryzyko wystąpienia objawów PPD nie różnicuje poziomu kortyzolu w surowicy i poziomu kortyzolu w mleku matki. Poziom kortyzolu w mleku matki odzwierciedla poziom kortyzolu w surowicy krwi badanych.

Słowa kluczowe

depresja poporodowa, Edynburska Skala Depresji Poporodowej, karmienie piersią, mleczny kortyzol, stężenie kortyzolu we krwi

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INTRODUCTION

Postpartum depression (PPD) is a very serious mental disorder that affects women worldwide. Research indicates that breast feeding is a protective factor against postpartum depression [1, 2], in turn, some analyses show that breast feeding is a risk factor for PPD symptoms [3, 4]. According to researchers, the level of cortisol in breast milk reflects the emotional state of the mother and predicts the temperament of the infant [5, 6, 7].

According to the hypothesis stated by Hechler et al., women who are breast feeding in highly stressful situations could physiologically signal the 'stressful environment' to their babies with the high level of hydrocortisone in their milk. Therefore, through the stress hormone contained in breast milk, infants adapt their behavioural phenotype to the prevailing environmental conditions [5]. Hinde described this concept as the 'lactation programming hypothesis', according to which the biological components of breast milk affect the metabolic and neurobiological development of the infant, which ultimately influences its behaviour and phenotype [6, 8].

The brain in infancy is characterized by neuroplasticity and a high level of sensitivity to external environment stimuli [8]. In turn, the gastrointestinal tract of infants has many receptors for glucocorticosteroids, enabling milk cortisol to cross the epithelial barrier of the intestines and then to overcome the blood-brain barrier and bind to the receptors of the limbic region, responsible for the regulation of emotions and behaviour [7, 9].

The first studies analysing the relationship between the level of milk cortisol and the baby's temperament assumed that the level of cortisol in the mother's plasma corresponds to the level of cortisol in her milk. It was observed that a higher level of cortisol in blood plasma – a higher level of cortisol in breast milk, was associated with a fearful attitude of infants [10] a higher level of sadness and fear in infants, characterized by a melancholic temperament [7].

It should be noted, however, that the relationship between the concentration of milk cortisol and the behaviour and temperament of infants may be bi-directional. Difficulties in baby care very often affect the occurrence of mental health disorders and worsen the overall quality of life of the mothers which, in turn, may determine higher concentrations of milk cortisol. On the other hand, infants exposed to maternal stress, which causes increased levels of cortisol in breast milk, may experience it by responding with crying and anxiety [11].

OBJECTIVE

The aim of the study was to determine whether there is a difference in the cortisol levels of breast milk and serum cortisol levels in women at risk of postpartum depression, but without symptoms. It was also checked whether there is a correlation between the level of cortisol in breast milk and the concentration of cortisol in the blood serum in the sample of women who were divided into three groups according to the duration of pregnancy. The study also provided an opportunity to determine the frequency of the risk of PPD symptoms in the study sample, in the fourth week after birth.

MATERIALS AND METHOD

75 newly-delivered mothers were qualified for the study. The research was conducted from April 2019 – January 2020. Permission to carry out the study was granted the Bioethics Committee (No. BC 121/2019).

The sample was obtained from the Department of Obstetrics, Women's Diseases and Oncological Gynecology of University Hospital No. 2, in Bydgoszcz. Information about the research project was also published on social media – on local groups for breastfeeding women. This increased the scope of the study and accelerated the recruitment process. Patients who initially agreed to participate in the study, both in the hospital and via social media, provided their contact details necessary to confirm their willingness to participate in the research project falling in the fourth week after childbirth. Participation in the research project was voluntary. The selection of study participants was deliberate. Ultimately, the study included women from the Warmińsko-Mazurskie (n = 1), Pomorskie (n = 5) and Kujawsko-Pomorskie (n = 69) Provinces. Before the examination, the obstetricians were informed about the purpose and course of the examination. The criteria for enrolling patients in the study included: breast feeding of the baby or breast milk expressed using a bottle/feeding tube, absence of depression in the history and anxiety and depression therapy during the last year, physical and mental condition enabling the expression the breast milk, independent completion of the questionnaire, and fasting on the day of the cortisol blood serum test.

The actual examination was performed during a meeting with the patient four weeks after delivery, on an agreed day and place. The study participants did not incur any costs related to the study. In return for participating they received the results of the analysis of the composition of milk and the level of cortisol in the blood serum. The patients and their immediate family were informed about the EPDS results when the value of the points obtained suggested a risk of postpartum depression symptoms.

Initially, 165 obstetricians were selected for the study, but only 75 were actually included in the study which was carried out in the fourth week after delivery. 90 obstetricians were excluded from participating in the research project due to stopped lactation and feeding the baby with modified milk. Most (78 obstetricians) did not breastfeed or express breast milk due to: sore nipples, recurrent food blockages, incorrect latching on to the breast, lack of family support, generalized obstetric fatigue. Four patients stopped breastfeeding for medical reasons. Eight obstetricians were not included in the study due to the death of their children (born below 32 weeks of gestation).

The average age of the studied sample of women was less than 31 years (30.99), with a median distribution of 31 years and a standard deviation of five years (5.24). The youngest was 20 years old and the oldest 46. Out of 75 respondents, the highest number had higher (57.33%) and secondary (30.67%) education. Only one woman (1.33%) declared primary education. A minority were women with vocational education (8%) and lower secondary education (2.67%) The vast majority of the respondents (69.33%) lived in the city, only one in three (30.67%) in the countryside. The vast majority of the surveyed women were multiparas (60%), 40% gave birth for the first time. All patients gave birth to one baby. Only 1/3 of the women surveyed (33.33%) gave

birth on time. In 50 examined women (66.66%), preterm delivery occurred, half of this group (33.33%) were mothers of late preterm infants (33–36 weeks of pregnancy). The remaining 33.33% of women gave birth before the 32nd week of pregnancy. In a small majority of women (50.67%), the pregnancy was terminated by a caesarean section. The most frequent (81.58%) emergency caesarean sections were performed in 31 patients, whereas 33% gave birth by natural labour.

Research tools. Standardised Edinburgh Postnatal Depression Scale (EPDS) research tools developed by Cox, Holden and Sagovsky [12] were used to assess the mood of newly-delivered mothers. The scale is copyrighted by the authors and the British Journal of Psychiatry. However, they agreed to reproduce and use the EPDS in the care of a newly-delivered mother for scientific purposes, provided that the source is acknowledged [13]. The EPDS is currently considered to be the most popular tool to assess the mood of newly-delivered mothers [14, 15] and consists of 10 statements describing aspects of well-being, such as anhedonia (claim 1 and nr 2), guilt (claim 3), anxiety (claim 4), panic attacks (claim 5), fatigue (claim 6), sleep disorders (claim 7), sadness (claim 8), tearfulness (claim 9), and suicidal thoughts (claim 10). The patient chooses one of the four possible answers which, in her opinion, best described her well-being, on a score of 0–3 points for each answer. The maximum number of points to be scored is 30. The higher the score, the greater the risk of postpartum depression. The literature of the subject indicates that the most frequent cut-off point in the conducted research is the result of 12–13 points. EPDS shows good psychometric properties. In the original study (score above 12 points), the test sensitivity was 86%, predictive accuracy 73%, specificity 78%, and the Cronbach's alpha reliability coefficient (α) 0.88 [12]. In the research carried out, the Cronbach's alpha reliability coefficient for the EPDS scale was estimated at 0.82, which is close to the reliability of the original version.

The study also used a questionnaire of own construction. The first part of the questionnaire included demographic questions concerning, among others: age of the respondents, place of residence, education and marital status. The next questions concerned the clinical data: duration of pregnancy, birth (primigravida/ multigravida) and the manner of finishing the pregnancy (natural labour/caesarean section).

Procedure for obtaining study material. Due to the daily rhythm of cortisol secretion, each patient's blood was collected between 08.00–08.15. Biochemical test-tubes with silica clot activators were used to determine the level of cortisol concentration in blood serum. The blood analysis was conducted in an ALAB Laboratory belonging to a nationwide network of laboratories in Poland. In order to ensure the right temperature, the biological material for analysis was transported in special packaging. All participants were informed about the correct preparation for the study: a few days before the planned study the patients eliminated or minimized nervous and stressful situations, stayed fasting on the day of the study (10–12 hours after the last meal), and did not take medication (after prior consultation with the attending physician). A glass of water was drunk a few minutes before blood collection.

On the same day, in order to analyse the cortisol level in the breast milk, the study participants expressed a portion of milk (20 ml) at about 08.30. The milk samples were then frozen and stored at -20°C for no more than three months. On the eve of the cortisol level test, samples of breast milk were left in the refrigerator overnight (4°C) to thaw. The level of cortisol in breast milk was determined by an immunoenzymatic method using a commercial test (CORTISOL saliva ELISA DiaMetra, Italy, 'Immuniq'). This method consists in the mutual competition of cortisol from the tested sample of breast milk and antigenic cortisol combined with horseradish peroxidase (conjugate) for binding with a limited number of anti-cortisol antibodies coated on a 96-well microplate. The colour absorption of the product was measured at 450 nm (nanometre) with a plate reader (MultiskanGo, Thermo Scientific, Finland).

Statistical analysis. The statistical analyses were developed using a statistical package (PQStat version 1.8.0.338). Results of biochemical scales of blood and milk composition depending on the group in terms of EPDS were compared with the Student's *t*-test (if the distributions did not differ significantly from the theoretical normal distribution), or with the Mann–Whitney *U* test (if the distributions differed significantly from the theoretical normal distribution). The relationship between serum cortisol levels and cortisol levels in breast milk was analysed by estimating Spearman's rank and Pearson linear correlation coefficients. The test probability value of $p < 0.05$ was considered significant.

RESULTS

Prevalence of postpartum depression. According to the DSM-V criteria, postpartum depression is diagnosed when the first depressive episodes appear up to four weeks after birth [16]. On this basis, it should be stated that the postpartum mood disorder in this study was postpartum depression. A score 12 or more points by the newly-delivered mothers on the Edinburgh Postnatal Depression Scale was accepted as the cut-off point. This result was considered as an indicator of the risk of symptoms of postpartum depression. The value of ≥ 12 points in EPDS was scored by 28% of respondents ($n=21$). No risk of postpartum depression symptoms was estimated at 72% ($n=54$).

Relationship between cortisol levels in breast milk and the risk of symptoms of postpartum depression. The Mann–Whitney *U* test did not find a difference between the level of cortisol in breast milk due to the risk of postpartum depression symptoms in the studied sample (Tab. 1). It should be noted, however, that the numerical average value of cortisol levels in milk of women without postpartum depression symptoms was higher than in the milk of women at risk of postpartum depression symptoms.

Relationship between serum levels of cortisol and risk of postpartum depression symptoms. Elevated serum cortisol levels may indicate, among others, chronic stress, sudden stress situations or depression. In the studies conducted, using statistical tests (Brown–Forsythe test, Student's *t*-test), no difference was found between serum cortisol levels and the risk of postpartum depression symptoms in the study

Table 1. Comparison of cortisol levels in breast milk [ng/100ml] regarding the risk of postnatal depression symptoms in the study sample

Item	Edinburgh Postnatal Depression Scale	
	NO POSTPARTUM DEPRESSION (<12)	POSTPARTUM DEPRESSION (>=12)
AM	16.38	14.49
MD	13.21	12.33
SD	12.12	8.78
Min.	5.328	4.71
Max.	86.84	40.65
Q ₁	9.59	8.37
Q ₃	20.54	18.27
The Mann-Whitney U test	Z	0.77
	p	0.44

AM – arithmetic mean; MD – median; SD – standard deviation; Min – minimum; Max – maximum; Q₁ – lower quartile; Q₃ – upper quartile

sample. However, it should be noted that the numerical mean value of serum cortisol levels in both studied groups was comparable (Tab. 2).

Table 2. Comparison of serum cortisol levels [ug/dl] regarding the risk of postpartum depression symptoms in the test sample

Item	Edinburgh Postnatal Depression Scale	
	NO POSTPARTUM DEPRESSION (<12)	POSTPARTUM DEPRESSION (>=12)
AM	15.86	15.69
MD	14.35	14.6
SD	5.79	3.83
Min	4.89	10.88
Max	34.91	24.21
Q ₁	11.44	12.74
Q ₃	20.16	17.93
Brown-Forsythe test	F	3.24
	p	0.08
	t	0.15
Student's t-test	df	54.98
	p	0.88

AM – arithmetic mean; MD – median; SD – standard deviation; Min – minimum; Max – maximum; Q₁ – lower quartile; Q₃ – upper quartile

Table 3. Correlation coefficient between serum cortisol levels [ug/dl] and breast milk cortisol levels [ng/ml]

Variable	Correlation	R	Error for r	-95% CI	+95% CI	T	df	P
In total	Pearson	0.2546	0.1132	0.0293	0.4552	2.249	73	0.0275
	Spearman	0.1092	0.1163	-0.1275	0.3341	0.9388	73	0.3509
EPDS<12	Pearson	0.3133	0.1317	0.0497	0.5361	2.3787	52	0.0211
	Spearman	0.2123	0.1355	-0.0669	0.4607	1.5668	52	0.1232
EPDS>=12	Pearson	-0.0716	0.2288	-0.4882	0.3716	-0.3127	19	0.7579
	Spearman	-0.1623	0.2264	-0.5645	0.3021	-0.7171	19	0.482
WP<32	Pearson	0.5178	0.1784	0.1542	0.7579	2.9025	23	0.0080
	Spearman	0.2131	0.2037	-0.2107	0.5694	1.0459	23	0.3065
WP33 – 36	Pearson	0.199	0.2043	-0.2128	0.5508	0.9739	23	0.3402
	Spearman	0.1019	0.2074	-0.3167	0.4873	0.4915	23	0.6278
WP >37	Pearson	0.0998	0.2075	-0.3075	0.4761	0.4808	23	0.6352
	Spearman	0.01	0.2085	-0.3971	0.4139	0.048	23	0.9622

EPDS – Edinburgh Postnatal Depression Scale; WP – weeks pregnant; R – Pearson's linear correlation coefficient; CI – confidence interval; T – test statistic, df – degrees of freedom

Correlation coefficient between serum cortisol levels in blood and cortisol levels in breast milk. The studied parameters were analysed by estimating Spearman's rank and Pearson correlation coefficients. In total, a significant ($p<0.05$), although low ($r=0.2546$), positive correlation between the level of cortisol in breast milk and serum cortisol concentration in the blood sample was found (Tab. 3). There were significant ($p<0.05$), low ($r=0.3133$) correlations between cortisol levels in breast milk and serum cortisol levels in the group of women without risk of postpartum depression symptoms (EPDS <12). In the group of women at risk of postpartum depression (EPDS ≥ 12), the correlation was insignificant ($p>0.05$).

The correlation relationship was analyzed between the level of cortisol in breast milk and the concentration of cortisol in the blood serum. Studies [17, 18, 19] show a relationship between the level of cortisol and the risk of PPD symptoms. Preterm labour is one of the most important risk factors for postpartum depression symptoms [20, 21]. The sample of surveyed women was divided into three groups according to the duration of pregnancy. Each group consisted of 25 respondents. The first group ($n = 25$) were women who gave birth before 32 weeks of gestation (TC <32), the second group gave birth between 33–36 weeks of pregnancy (TC 33–36). The third group consisted of respondents who gave birth after 37 weeks of pregnancy (TC > 37). A highly significant correlation ($p < 0.01$) was found at the average level ($r = 0.5178$) between the level of cortisol in breast milk and the concentration of cortisol in the blood serum in the group of women whose pregnancy ended below 32 weeks of pregnancy. In the remaining groups (TC 33–36, TC > 37), the correlation was insignificant.

There was a highly significant correlation ($p < 0.01$) at an average level ($r = 0.5178$) between the level of cortisol in breast milk and serum cortisol concentration in the group of women whose pregnancy was terminated below 32 weeks of gestation. In the remaining groups (WP 33–36, WP >37) the correlation was insignificant.

DISCUSSION

Data on the prevalence of risk of postpartum depression vary according to the study criteria adopted, the research tools

used, the sample selection and the study duration [22]. The risk of postpartum depressive symptoms on the Edinburgh Postpartum Depression Scale (≥ 12 points) in the fourth week after birth was 28%. In the largest meta-analysis and meta-regression so far conducted, 291 studies with 296284 women from 56 countries, it was found that the global prevalence of PPD risk was 17.7%. The meta-analysis revealed large differences in the incidence of PPD risk ranging from 3% in Singapore to 38% in Chile. The countries with the highest PPD incidence rates are Turkey 28%, Hong Kong 30%, South Africa 37%, and the aforementioned Chile 38%. The lowest PPD incidence rates were recorded in Singapore 3%, Nepal 7%, The Netherlands 8% and Switzerland 11%. It should be noted that the meta-analysis included studies with a comparable sample size, PPD time assessment and EPDS cut-off point (≥ 12 points). Differences in the incidence of risk of PPD symptoms in individual countries are mainly due to the economic situation of countries [23].

For the next meta-analysis on the prevalence of PPD symptoms risk in more than 50 countries, 124 scientific studies were included. The overall risk prevalence of PPD symptoms ranged from 4% in Japan to 63.9% in America. On the basis of the meta-analysis, significant differences in PPD prevalence across continents were observed. In Australia, the prevalence of PPD ranged from 6% – 32.8%, in Europe 4.4% – 22.8%, in America 5% – 63.9%, in Africa 7.2% – 50.3%, and in Asia 4% – 48.3%. Asian countries have also found large variations in the prevalence of PPD, as exemplified by India and China, where PPD prevalence rates ranged from 15.8% to 46.9% and 9.4% to 27.4%, respectively [24]. Comparable PPD frequency indices to the presented study are presented in a meta-analysis, on the basis of which an overall PPD prevalence of 27% was found. Moreover, it was observed that the prevalence of PPD was lower in developed countries (21.5%) than in developing countries (31.3%) [25].

Researchers from Canada indicate that the risk prevalence of PPD symptoms is at 40% [26]. In Sudan, the risk of PPD symptoms was estimated at 9.2% [27] and in Jamaica – 34% [26]. A literature review indicates that the prevalence of the risk of symptoms of postpartum depression ranges from 1.9% – 82.1% [22, 28]. *'Some researchers specify that 10 to nearly 30% of women are at risk of postpartum depression'* [29]. On a sample of 70 women in the fourth week after childbirth, using the EPDS, showed the risk of PPD symptoms at the level of 18.6% [30]. The results obtained in the current study concerning the frequency of the risk of postpartum depression symptoms based on the EPDS scale four weeks after childbirth, fall within a wide range of results obtained from foreign studies. It is worth noting that the frequency of the risk of PPD symptoms in this study may be higher due to the fact that 2/3 of the studied sample were mothers of preterm babies. Both preterm birth and preterm birth-related low birth weight, poor health of the baby and low Apgar scores, are scientifically reported as risk factors for PPD symptoms [31, 32].

The current analysis did not show any difference between the level of cortisol in breast milk and the risk of postpartum depression symptoms. However, it was observed that the average level of cortisol in female milk in the study sample with no risk of postpartum depression was higher (Tab. 2) than in the study sample with a risk of postpartum depression. There are no studies in the literature assessing the possible impact of postpartum depression

on cortisol levels in breast milk. However, researchers are increasingly interested in the influence of cortisol levels in breast milk on the offspring phenotype [7, 8]. Dettmer et al. [33] believe that already during pregnancy, the mother's body sends physiological signals to the developing foetus, which affects the baby's behavioural profile adapted to the environment in which it will grow up. When feeding natural milk, mothers may continue to transmit information to their baby using the biological components of the milk, including cortisol [34].

Since there is no synthesis of cortisol in the mammary gland, the level of cortisol concentration is transferred from plasma to breast milk [35]. According to the foetal programming hypothesis, it can be concluded that when a woman suffers from depression during pregnancy this information is passed on through cortisol to babies who can adapt their behavioural phenotype to the future environment in which they will grow up after birth. This means that women with higher levels of cortisol in breast milk experience more negative emotions in their lives or suffer from depression [36].

In the current study, no correlation was found between serum concentrations of cortisol and the risk of postpartum depression symptoms (Tab. 3). In turn, Seth et al. [36] in their systematic literature review indicate a relationship between cortisol levels and postpartum depression. Groër et al. [37] assessed the level of cortisol after delivery and viewed postpartum depression as a categorical variable. In research in which 200 women participated between four and six weeks postpartum, the level of cortisol was tested in saliva between 08.00–11.00, and the risk of postpartum depression symptoms assessed by using the Profile of Mood States questionnaire. The results of the study suggest that women at risk of PPD symptoms had a lower hypothalamic-pituitary-adrenal axis (HPA) because they showed significantly lower levels of cortisol in saliva than women without risk of PPD symptoms. The authors of the study also observed that women with PPD resigned from breast feeding more quickly, and the level of prolactin in blood serum was lower than in the control women sample [37]. Similar conclusions are presented by Taylor et al. who documented the absence of an expected increase in cortisol levels examined in saliva 30 minutes after awakening in women at risk of PPD symptoms. The authors also indicated the weakening of sensitivity of the hypothalamo-pituitary-adrenal axis to endogenous stimulus (awakening) in women with PPD symptoms [38]. Lower serum levels of cortisol in women with PPD symptoms were also shown by Harris et al. and Tsubochi et al [17]. The literature of the subject points to studies in which, similarly to the own study, no correlation was found between serum cortisol concentration and the risk of PPD symptoms [18, 19]. In their study, Nierop et al showed a link between high levels of cortisol in response to an external stimulus and the risk of PPD symptoms. Women with high levels of cortisol between 13 and 31 weeks of pregnancy were at greater risk of PPD symptoms between two and 27 days after birth [39]. Other researchers have also shown a relationship between high levels of cortisol concentration and the risk of PPD symptoms [40, 41]. The study showed a positive correlation between the level of cortisol in breast milk and the serum concentration of cortisol in the studied sample. Lee et al. observed a correlation between cortisol levels in saliva and free cortisol levels in plasma and serum [42].

Advantages and limitations of the study. To the best of our knowledge this study is the first to focus on the relationship between the onset of symptoms of postpartum depression and the assessment of cortisol levels in breast milk and blood serum. There are no scientific reports on the correlation between the level of cortisol in breast milk and the concentration of cortisol in blood serum. The advantage of this study is the use of advanced techniques for the assessment of human milk which allowed the minimalisation of possible errors in the assessment of the composition of human milk. In addition, the milk and blood serum sampling procedure has been carefully planned and carried out to minimize errors due to physiological factors.

There are also some limitations to this study. First, the study was conducted with a small number of participants and further large-scale studies in a variety of populations are warranted. Secondly, there is no available literature that presents the results of studies on the relationship between the occurrence of symptoms of postpartum depression and the assessment of cortisol levels in breast milk and blood serum, nor on the correlation between the level of cortisol in human milk and the concentration of cortisol in blood serum, therefore the obtained results of this study cannot be compared with the research of other authors.

CONCLUSION

1. The current study shows that both the levels of cortisol and blood serum did not differ in the group of women with and without the risk of postpartum depression symptoms.
2. In the absence of scientific reports in this area, it is considered that the results of the study will be important not only for medical staff caring for a newly-delivered mother at risk of symptoms of postpartum depression, but above all, for women with PPD who will decide how to feed their baby.

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