Evaluation of the Vitamin Status in Nursing Women by Vitamin Content in Breast Milk

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The dependence of daily vitamin excretion with breast milk on dietary vitamin content and blood vitamin level was studied in nursing women. Breast mils vitamins were assayed in women supplied with vitamins. We identified the criteria for adequate vitamin supply in nursing women over the 1st month after labor (vitamins A, 130 μg; vitamin B_1, 100 μg; vitamin B_2, 130 μg; vitamin E, 750 μg; vitamin B_6, 60 μg).

Key Words: *vitamins; breast milk; nursing women; vitamin supply*

Much recent attention is paid to noninvasive methods to study vitamin supply. There are nontraumatic and painless methods to measure the concentration of vitamins in saliva, breast milk, spermoplasm [3], bronchial lavage fluid, lachrymal fluid, and sweat. This approach not only allows us to perform repeated tests, but also decreases the risk of infection. However, the concentration of breast milk vitamins reflecting vitamin supply in nursing women remains unknown.

The criteria for adequate vitamin supply in nursing women were evaluated by the daily excretion of vitamins with breast milk. We studied the dependence of vitamin excretion with breast milk on dietary vitamin content. The relationship was determined between daily excretion of vitamins with breast milk and blood vitamin level in women. Breast milk vitamins were assayed in women supplied with vitamins (treatment with multivitamin complexes).

MATERIALS AND METHODS

Forty-three women (19-35 years) with preterm delivery (29-36 weeks' gestation) were examined at the Scientific Center of Child Health (Russian Academy of Medical Sciences). Thirty-five nursing women with normal delivery (38-40 weeks' gestation) were examined at the Maternity Hospitals No. 6 and No. 32 (Central Administrative District, Moscow) and Lyubertsy Maternity Hospital.

The dietary regimen of 26 nursing women with preterm delivery was studied at home taking into account the amount of major food ingredients and dietary vitamins (method of feeding reproduction) [6]. Questioning and questionnaire filling were performed 2 times a week over 2 weeks. The dietary regimen of 25 nursing women with normal delivery was studied in the maternal hospital. The content of major food ingredients and dietary vitamins was estimated by master menu. We took into account the type of food products and vitamin complexes given by relatives. Some women received multivitamin complexes Materna, Vitrum Prenatal, Gendevit, Revit, Pregnavit, and Elevit during pregnancy and after labor. The results were analyzed by means of software and databank of the Laboratory for Study of Food Patterns (Institute of Nutrition, Russian Academy of Medical Sciences). We used the data published previously [5].

Vitamin supply in nursing women was determined by serum concentration of vitamins A, E, B_2, and B_6 [9]. The concentrations of vitamin A, vitamin E, riboflavin, and vitamin B_6 coenzyme in the plasma from adults with adequate vitamin supply are 30-70 μg/dl, 0.8-1.5 mg/dl, 5-20 ng/ml, and 6-25

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ng/ml, respectively [9]. The women were considered to be inadequately supplied with vitamins when blood vitamin level was below the lower limit of normal.

Vitamin content was measured in 24-h samples of expressed breast milk obtained from preterm-delivery women on days 14-20 of lactation. The milk was homogenized. Milk samples were stored at -20°C.

Vitamin content in breast milk of normal-delivery women was measured on days 3-10 of lactation. A single sample of breast milk from fasting women was taken in the morning and stored at -20°C. The volume of lactation was determined by weighing infants before and after breast feeding. The results of a 24-h study were summarized.

Vitamin C concentration in freshly expressed milk was determined by the method of visual titration [8]. Vitamin B_2 concentration in the plasma and milk was estimated spectrophotometrically by the method of titration with riboflavin-binding apoprotein [9]. Vitamins B_6, A, and E were assayed by means of high-performance liquid chromatography [8,9]. The presence of vitamin B_1 in breast milk was determined the thiochrome method [8]. We took into account published data to estimate the concentrations of vitamins C, A, E, and B_6 [4].

The results were analyzed by Student's *t* test. The data are expressed as $M \pm m$.

RESULTS

We determined the limits of variations in breast milk vitamins (Table 1). The results of our study were compared with published data. The estimated values corresponded to the range of vitamin concentration in nursing women (except for vitamin B_2) [1,10,13]. No differences were revealed in the concentration of vitamins in a single sample of milk from normal-delivery women and 24-h milk samples from preterm-delivery women. Our findings are consistent with published data that vitamin E secretion practically does not differ in women with preterm and normal delivery [13]. The discrepancy of data on vitamin B_2 content was probably associated with differences in the method of vitamin assay [9]. The concentration of vitamins was high in breast milk of women with regular vitamin consumption. The differences in the concentration of vitamins B_1 and B_2 were statistically insignificant.

Daily lactation and milk vitamin content undergo significant individual variations (by 2-7 times) [1,10,13], therefore vitamin excretion was studied in 24-h samples of breast milk.

Further studies were performed to evaluate the relationship between dietary vitamin content, plasma vitamin concentration, and vitamin excretion with breast milk of nursing women. We constructed the dependence curves (Figs. 1 and 2) and calculated the coefficients of correlation between individual pairs of parameters for each vitamin (Table 2).

A strong positive correlation was found between the concentrations of vitamins C, A, B_1, and B_2 in food products and milk of women with preterm and normal delivery (Table 2). Increasing the concentration of dietary vitamins was accompanied by an increase in their excretion with breast milk (Fig. 1). Daily excretion of vitamins with breast milk

TABLE 1. Concentration of Vitamins in Breast Milk of Women with Different Vitamin Supply

Group, parameter	Published data [1,10,13]		During pregnancy and feeding	
	no vitamin supply	adequate vitamin supply	no vitamin supply	adequate vitamin supply
Normal-delivery women	(*n*=6)		(*n*=15)	
vitamin C, mg/liter	20-85	35-100	32±10 (20-43)	85±20 (53-116)
vitamin B_1, μg/liter	160-220	220-238	92±21 (23-175)	238±49* (107-637)
vitamin B_2, μg/liter	475-580		266±40 (81-358)	330±41 (152-600)
daily lactation, ml	—	—	420±26 (330-500)	477±54 (225-750)
Preterm-delivery women	(*n*=6)		(*n*=6)	
vitamin A, μg/liter	150-2260		280±50 (120-630)	320±40 (240-450)
vitamin E, μg/liter	1000-4800		2100±200 (1370-3490)	2600±300 (1900-3700)
vitamin B_1, μg/liter	80-230		150±30 (114-212)	210±30* (130-280)
vitamin B_2, μg/liter	200-790		250±80 (22-340)	410±50* (240-550)
vitamin B_6, μg/liter	100-220		100±10 (80-120)	120±10 (100-150)
daily lactation, ml	—	—	307±90 (190-1000)	550±129 (270-1000)

Note. *$p \leq 0.05$ compared to women not receiving the vitamins. The range of variations is shown in brackets.

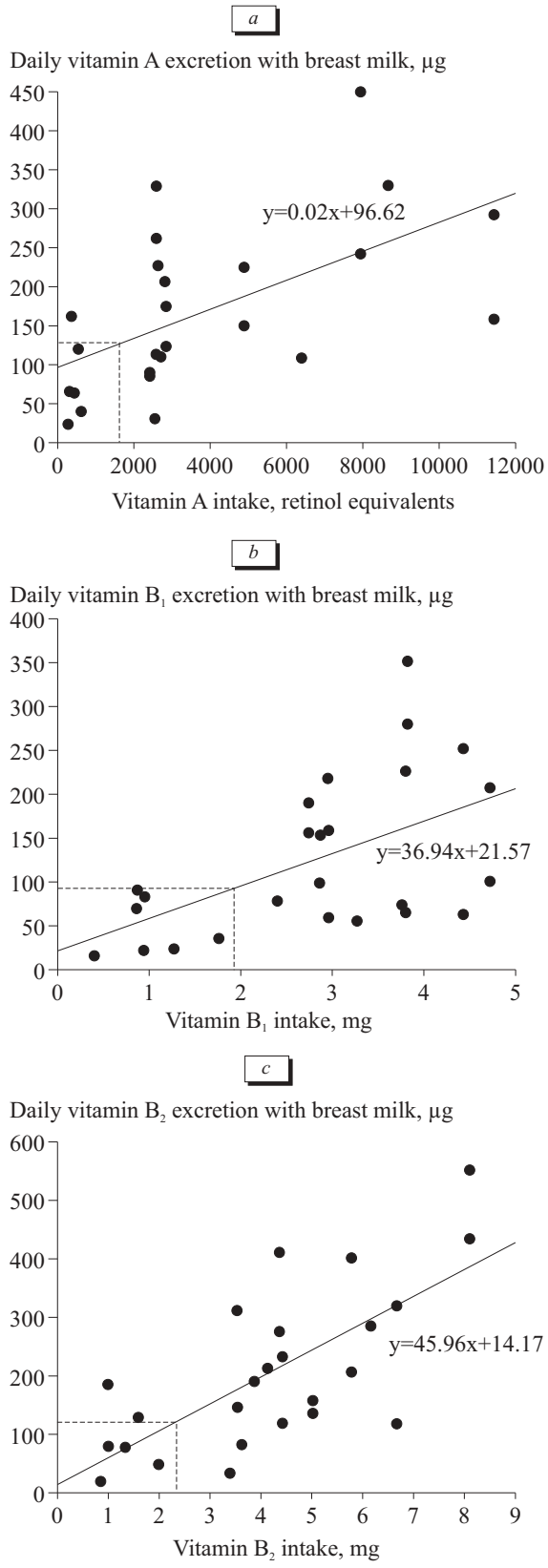

Fig. 1. Dependence of excretion of vitamins A (*a*), B_1 (*b*), and B_2 (*c*) with breast milk of preterm-delivery women on daily vitamin intake. Vertical dotted line, recommended vitamin intake; horizontal dotted line, vitamin excretion with breast milk.

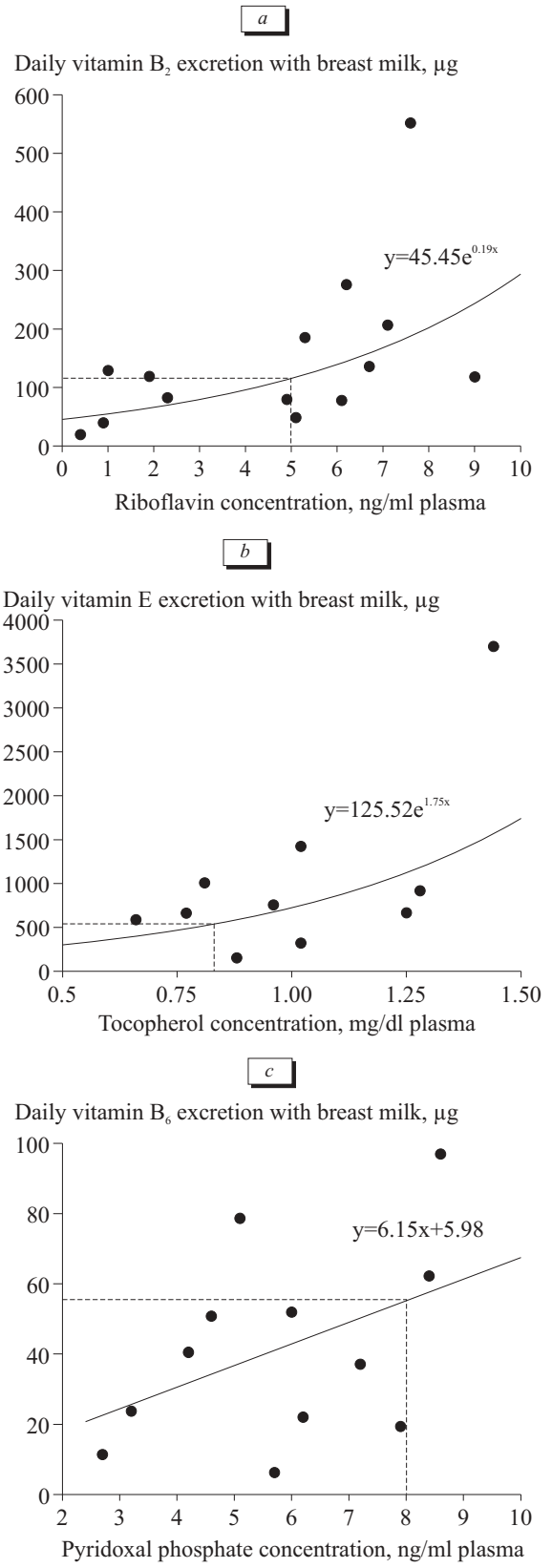

Fig. 2. Dependence of excretion of vitamins B_2 (*a*), E (*b*), and B_6 (*c*) with breast milk of preterm-delivery nursing women on plasma vitamin concentration. Vertical dotted line, lower limit of plasma vitamin concentration; horizontal dotted line, vitamin excretion with breast milk.

TABLE 2. Coefficients of Liner Correlation between Dietary Vitamin Content and Concentration of Vitamins in the Plasma and 24-h Samples of Breast Milk in Nursing Women

Vitamin	Pair of parameters	Preterm delivery			Normal delivery		
		n	*R*	*P*	*n*	*R*	*P*
A	Dietary regimen — milk	26	0.585	0.002	—		—
E	Blood — milk	13	0.624	0.01	—	—	—
C	Dietary regimen — milk	—	—	—	12	0.841	0.01
B_1	Dietary regimen — milk	26	0.556	0.004	23	0.751	0.001
B_2	Dietary regimen — milk	26	0.701	0.001	25	0.739	0.001
	Blood — milk	13	0.602	0.01	—	—	—
B_6	Blood — milk	13	0.444	0.05	—	—	—

Note. *n*, number of examined women; *R*, correlation coefficient; *P*, significant differences (Student's test).

corresponding to recommended vitamin intake [7] was determined by a linear correlation (Fig. 1, *a*, *b*, *c*).

A correlation was revealed between the concentrations of vitamins E, B_2, and B_6 in the blood and milk (Table 2). In women with normal level of vitamins in blood plasma, daily excretion of vitamins B_2, E, and B_6 with breast milk exceeds 116, 510, and 55 μg, respectively (Fig. 2, *a-c*). Study of two dependence curves revealed no differences in the daily excretion of vitamin B_2 with breast milk (Fig. 1, *c*; Fig. 2, *a*). This level of vitamin excretion is typical of women with adequate vitamin supply.

The criterion for vitamin supply in nursing women was determined by the amount of vitamins excreted with breast milk over the 1st month of lactation. The concentration of vitamins was measured in breast milk of 12 term-delivery women with adequate vitamin supply and 11 preterm-delivery women receiving vitamins during pregnancy and after labor. No differences were found in the concentrations of vitamins B_1 and B_2 in 24-h samples of breast milk from these women (Table 3). Our results provide indirect evidence that the demands for essential vitamins is similar in full-term and premature newborns during the neonatal period [2,5].

The daily excretion of vitamins with breast milk can serve as a criterion for adequate vitamin supply in nursing women (Table 3). The daily excretion of vitamins in breast milk of nursing women with adequate vitamin supply corresponds to recommended vitamin intake for infants of 0-6 months [11,12]. These criteria can be used not only to estimate noninvasively the vitamin status of nursing women, but also to determine the adequacy of vitamin intake and vitamin supply in breast-feeding infants. It should be emphasized that breast milk is the only food source for infants.

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TABLE 3. Lower Limits (Criterion for Normal Supply) of Daily Vitamin Excretion in Breast Milk of Nursing Women with Adequate Vitamin Supply (1st Months, Various Methods of Study)

Vitamin	Dependence for calculation		Vitamin excretion with breast milk (*M*±*m*)		Criterion for adequate supply in women
	breast milk — dietary regimen	breast milk — blood	normal delivery (*n*=12)	preterm delivery (*n*=11)	
A, μg	125	—	—	170±31	130
B_1, μg	92	—	114±21	121±39	100
B_2, μg	115	116	162±36	235±77	130
E, μg	—	510	—	1504±493	750
B_6, μg	—	55	—	62±11	60

Note. *n*, number of examined women.

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