Breast milk docosahexaenoic acid (DHA) correlates with DHA status of malnourished infants

Ella N Smit, Esther A Oelen, Ejaz Seerat, Frits A J Muskiet, E Rudy Boersma

Departments of Obstetrics and Pediatrics, Perinatal Nutrition and Development Unit, Groningen University Hospital, Groningen, Netherlands
E N Smit
E A Oelen
E R Boersma

Department of Pathology and Laboratory Medicine, Groningen University Hospital
F A J Muskiet

Federal Government Services Hospital, Department of Pediatrics, Nutrition Rehabilitation Center, Islamabad, Pakistan
E Seerat

Correspondence to: Dr E N Smit, c/o Prof. Dr E R Boersma, Department of Obstetrics and Gynecology/Pediatrics, Perinatal Nutrition and Development Unit, University Hospital Groningen, Dept CMC 5, k.Y.3179, PO Box 30.001, 9700 RB Groningen, Netherlands
email: e.r.boersma@med.rug.nl

Accepted 4 February 2000

Abstract

***Aim*—To investigate whether low docosahexaenoic acid (22:6ω3; DHA) status of malnourished, mostly breast fed infants is a result of low ω3 fatty acid intake via breast milk.**

***Methods*—Fatty acid composition of breast milk of eight Pakistani mothers, and of the erythrocytes of their malnourished children was analysed.**

***Results*—The milk of the Pakistani mothers contained low percentages of all ω3 and most ω6 fatty acids, compared with milk of Dutch mothers. Breast milk DHA was positively correlated with infant erythrocyte DHA and arachidonic acid (20:4ω6).**

***Conclusion*—DHA status of these malnourished children is strongly dependent on the ω3 fatty acid intake from breast milk. Augmentation of the infants' ω3 long chain polyunsaturated fatty acid status, or the ω3 and ω6 fatty acid status in general, by supplementation is indicated in deprived circumstances where access to fresh fish is difficult. However, in terms of prevention, maternal supplementation of these long chain polyunsaturated fatty acids, preferably from early pregnancy onwards, may be a better option.**

(*Arch Dis Child* 2000;**82**:493–494)

Keywords: fatty acid; docosahexaenoic acid; malnourished; breast milk

Postnatal docosahexaenoic acid (22:6ω3; DHA) status has been found to be related to visual acuity, neurodevelopment, and behaviour. DHA and other long chain polyunsaturated fatty acids (LCPUFA) are widely considered to be essential in the prenatal and early postnatal periods, because the synthesis of LCPUFA from their precursors, α-linolenic acid (18:3ω3; ALA) and linoleic acid (18:2ω6; LA), does not seem to cover the infants' high needs at this stage of development. Breast milk contains in general a sufficient quantity of LCPUFA, including DHA and arachidonic acid (20:4ω6; AA) to serve these needs. However, the LCPUFA composition of human milk is to a great extent dependent on the maternal diet.[1] Therefore in North Pakistan, low breast milk ω3 (LC)PUFA levels might be expected, because of the predominant use of ALA poor corn oil and ghee, the low intake of green leafy vegetables (a source of ALA), and almost no consumption of (ω3LCPUFA rich) fish.[2] In a previous study we found low erythrocyte (RBC) DHA levels in malnourished, mostly breast fed, 4–56 month old children, living in and around Islamabad, North Pakistan.[3]

We hypothesised that the low RBC DHA content in these infants was a result of low ω3-LCPUFA intake via breast milk. In an attempt to test this hypothesis we studied the FA composition of both the breast milk of eight Pakistani mothers and that of the RBC of their malnourished children.

Subjects and methods

The study population consisted of eight mother–child pairs from a low socioeconomic class. They were recruited from the Nutrition Rehabilitation Center of the Pediatric Department, Federal Government Services Hospital, Islamabad. The children were classified as malnourished, defined as weight for age below the mean minus 2SD, according to WHO growth charts. EDTA anticoagulated blood (2.5 ml at most) of the children was taken in an undefined metabolic state. Breast milk samples were collected by manual expression. Fatty acids (FA) were determined as their methyl esters by capillary gas chromatography with flame ionisation detection.

Milk FA composition of Pakistani mothers was compared with previously collected mature milk FA data of 25 Dutch mothers. Between group differences were analysed using the Mann–Whitney U test at $p < 0.05$. Correlations of the different PUFA between breast milk and infant RBC, and between the various PUFA in infant RBC were tested with the Spearman test at $p < 0.05$.

Results

The median (range) duration of lactation of the Pakistani mothers was 12.5 (4.5–21) months. Table 1 shows the breast milk FA composition, together with the data of the Dutch mothers on postnatal day 89 (77–103). Milk of Pakistani mothers contained significantly lower amounts of all ω3FA. Among the ω6FA, LA, 18:3ω6, 20:2ω6, 20:3ω6, and AA contents were significantly lower.

Breast milk DHA and infant RBC DHA were strongly correlated ($r = 0.8571$, $p = 0.007$). Breast milk DHA correlated positively with infant RBC AA ($r = 0.7857$, $p = 0.021$), but negatively with 18:1ω9 ($r = -0.8571$, $p = 0.007$). Milk eicosapentaenoic acid (20:5ω3; EPA) correlated with infant RBC DHA ($r = 0.7186$, $p = 0.045$). There were no other significant correlations between milk PUFA and infant RBC PUFA.

There was a positive correlation between infant RBC DHA and infant RBC AA ($r = 0.8571$, $p = 0.007$).

Table 1 Fatty acids in mature human milk of Pakistani mothers of malnourished children compared with Dutch controls

	Pakistani (n = 8)		Dutch (n = 25)	
ω3 series				
18:3ω3	0.34	(0.28–0.51)*	1.12	(0.64–2.19)
20:5ω3	0.02	(0.01–0.09)§	0.05	(0.00–0.29)
22:5ω3	0.05	(0.04–0.14)†	0.13	(0.09–0.22)
22:6ω3	0.06	(0.04–0.14)†	0.14	(0.10–0.65)
sumω3	0.53	(0.37–0.64)*	1.45	(0.90–2.54)
LCPUFAω3	0.13	(0.09–0.29)†	0.32	(0.23–1.17)
ω6 series				
18:2ω6	8.73	(7.45–10.61)†	13.84	(6.44–27.69)
18:3ω6	0.05	(0.03–0.12)‡	0.10	(0.06–0.19)
20:2ω6	0.15	(0.14–0.17)*	0.25	(0.18–0.37)
20:3ω6	0.21	(0.15–0.36)†	0.29	(0.18–0.43)
20:4ω6	0.26	(0.20–0.44)§	0.33	(0.24–0.43)
22:4ω6	0.06	(0.04–0.08)	0.06	(0.04–0.08)
22:5ω6	0.02	(0.00–0.04)	0.02	(0.00–0.04)
sumω6	9.35	(8.22–11.69)†	14.80	(7.40–28.97)
LCPUFAω6	0.69	(0.57–0.96)†	0.96	(0.77–1.22)

Data represent median (range), and are expressed in mol% (mol/100 mol). Duration of lactation: Pakistan (median 12.5; range 4.5–21 months); Netherlands (mean 89; range 77–103 days).
*$p < 0.0001$; †$p < 0.005$; ‡$p < 0.001$; §$p < 0.05$.
LCPUFA, long chain polyunsaturated fatty acid (C ⩾ 20, at least three double bonds).

In summary, milk of Pakistani mothers contained low percentages of all ω3 and most ω6 fatty acids, compared with milk of Dutch mothers. Breast milk DHA and EPA were positively correlated with infant RBC DHA, while milk DHA was also associated with infant RBC AA.

Discussion

Milk of Pakistani mothers feeding malnourished children was found to contain low percentages of all ω3PUFA and most ω6PUFA (LA, 20:2ω6, 20:3ω6, and AA) compared to milk of Dutch mothers. As the milk FA composition is largely dependent on the maternal diet[1] it is conceivable that the above differences reflect nutritional differences. The low Pakistani milk ω3LCPUFA content is presumably caused by low fish consumption in North Pakistan.[2] In this respect it is noteworthy that fish intake in the Netherlands is also considered to be low, which is reflected in relatively low plasma phospholipid DHA content compared to other countries.[4] The milk ω3-LCPUFA contents were nevertheless two times lower in the Pakistani than in the Dutch samples.

A strong positive correlation between breast milk DHA concentrations and infant plasma and RBC phospholipid DHA in 12 week old exclusively breast fed children has been reported by Gibson *et al*.[5] Similarly, we observed a strong correlation between breast milk DHA and EPA contents on the one hand and infant RBC DHA content on the other hand. This is of particular interest, as the children in the present study were much older (4.5–21 months) and weaned. It suggests that the DHA status of these malnourished children is still strongly dependent on the DHA and EPA intake from breast milk and probably much less on the ω3PUFA intake from weaning food. Prolonged breast feeding of these malnourished Pakistani children seems therefore not only important for its anti-infective properties and other favourable effects, but also as the major source of dietary ω3LCPUFA.

Apart from the adequate supply of LCPUFA, many other factors are important for cognitive function. Overall nutritional status, iron, iodine, and zinc deficiency, all seem to be related to mental development. Finally, poor social and family circumstances and a less stimulating environment could also affect later achievements. These unfavourable conditions do prevail in circumstances where malnutrition is often encountered.[6]

Nevertheless, the very low DHA status of these children is a matter of concern, because of its potentially adverse effects on brain development, including that of the retina.[1] Regarding the poor ω3LCPUFA status of their mothers, it may be expected that this condition was already present during gestation and immediately after birth, exposing the vulnerable fetus and neonate to low concentrations of ω3LCPUFA.

Milk DHA was also positively associated with infant RBC AA. Moreover, infant RBC DHA and AA were positively correlated. Others have suggested that ω6FA cannot accumulate normally in cell membranes when ω3FA supply is low.[7] It is therefore tempting to speculate that the low DHA intake by these malnourished children may not only cause low RBC DHA concentrations, but may also have adverse effects on AA status.

Augmentation of the infants' ω3LCPUFA status, or the ω3 and ω6FA status in general, by supplementation is indicated in deprived areas where access to fresh fish is difficult. Fish oil seems to be the most logical supplement. As purified fish oil is rather expensive, the cheaper cod liver oil could be a useful alternative. Moreover, cod liver oil contains vitamins A and D. Malnourished children often suffer from a deficiency of these essential nutrients as well.

However, future efforts could be better directed at the supplementation of these LCPUFA to Pakistani women from early pregnancy onwards in order to prevent any adverse affects on perinatal brain development of the child. By doing so both the low transplacental supply to the fetus and a low postnatal supply to the newborn via breast milk could be avoided. Consequently, the LCPUFA status of early brain development could be improved.

1 Hamosh M, Salem N Jr. Long-chain polyunsaturated fatty acids. *Biol Neonate* 1998;**74**:106–20.
2 National Institute of Health, Government of Pakistan, Nutrition Division. *National nutrition survey 1985–87*. Islamabad: PanGraphics Ltd, 1988.
3 Smit EN, Dijkstra JM, Schnater TA, Seerat E, Muskiet FAJ, Boersma ER. Effects of malnutrition on the fatty acid composition and plasma vitamin E levels of Pakistani children. *Acta Paediatr* 1997;**86**:690–5.
4 Otto SJ, v Houwelingen AC, Antal M, *et al*. Maternal and neonatal essential fatty acid status in phospholipids: an international comparative study. *Eur J Clin Nutr* 1997;**51**: 232-42.
5 Gibson RA, Neumann MA, Makrides M. Effect of increasing breastmilk docosahexaenoic acid on plasma and erythrocyte phospholipid fatty acids and neural indices of exclusively breast fed infants. *Eur J Clin Nutr* 1997;**51**:578-84.
6 Simeon DT, Grantham-McGregor SM. Nutritional deficiencies and children's behaviour and mental development. *Nutr Res Rev* 1990;**3**:1–24.
7 Bjerve KS, Fischer S, Wammer F, Egeland T. α-Linolenic acid and long-chain ω-3 fatty acid supplementation in three patients with ω-3 fatty acid deficiency: effect on lymphocyte function, plasma and red cell lipids, and prostanoid formation. *Am J Clin Nutr* 1989;**49**:290–300.