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Role of Maternal Dietary Intake on Fatty Acids in Human Milk: A Systematic Review

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ABSTRACT: Human milk is the main source of food for young infants up to 6 months of age. During initial period of lifecycle, lipids in human milk predominate the health of an individual as a whole. Lipids form the principle source of nutrition in an infant .Therefore, the sort of fatty acids in human milk directs the growth and development of infants. Lipids in human milk vary based on the dietary intake of the mothers. This paper strives to summarize accessible studies related to maternal dietary intake during pregnancy and lactation and its impact on composition of fatty acids in human milk. On the whole11 studies were selected to review. These studies basically examined maternal dietary intake and its effect on essential fatty acids, vitamin A and vitamin D in human milk. Results: Maternal Dietary intake of vitamin A, DHA positively influences its level in human milk. Supplementation of DHA in prenatal and postnatal mothers increases DHA levels in milk for both preterm and term infants.

KEY WORDS: Essential fatty acids, human milk, breast milk, breastfeeding, infant nutrition, LC-PUFA, DHA, Arachidonic acid,n-3 fatty acids, n-6fatty acids, maternal diet, maternal intake, fat soluble vitamins.

INTRODUCTION

Human milk forms an integral part of infant's nourishment from birth up to 6 months of age. Levels of fatty acids in Human milk are highly susceptible to maternal nutrition and are involved in neurological development. At birth infant brain weighs 350 g and by end of 1 year it weighs 925 g. This rapid growth includes major dendritic and axonal arborization. (1)

Dietary lipids provide essential fatty acids (EFAs) and facilitate the absorption of lipid-soluble vitamins. Lipids are the main energy source in infant diet and are therefore necessary for growth and physical activity .Fats provide around half of the energy in human milk (and in most artificial formulas).Fatty acids in diet influence evolution of nutrition related chronic diseases. This has received extensive scientific thought from worldwide. Lipids constitute as one of the basic units of body tissues and are imperative in formation of membranes and cell organelles. Long-chain polyunsaturated fatty acids (LCPs) are chiefly located in the brain, retina and other neural tissues. Physiological functions such as thrombocyte aggregation, inflammatory responses, leukocyte migration, vasoconstriction, vasodilatation, blood pressure, bronchial constriction, uterine contractility, apoptosis and reperfusion oxidative damage are monitored by LCPs.(2)

Cardiovascular morbidity and mortality in later life is influenced by cholesterol metabolism at an early age .Among the fatty acids, humans cannot synthesize the n-3 and the n-6 families of polyunsaturated fatty acids. Dietary intake of parent fatty acids from the families of alpha-linolenic acid (ALA) and linoleic acid (LA) are indispensable. Both n-3 and n-6 families of fatty acids are essential as they cannot be interconverted. ALA and LA are converted to longer chain, more highly unsaturated fatty acids through enzymatic chain elongation and desaturation .ALA is converted to eicosapentaenoic acid (EPA C2:5n-3) and to docohexaenoic acid (DHA C2:6n-3), while LA is converted to arachidonic acid (AA).DHA is a vital component of cell membranes, especially in the brain and the retina. Substantial amount of DHA in cerebral cortex and retinal phospholipids emphasizes significance of n-3 fatty acids for brain and visual function .There are higher chances that nervous system manifestations may be due to deficiency of n-3 fatty acids with special consideration to DHA deficit. AA is both a membrane component and a precursor to potent signaling molecules, the prostaglandins and leukotrienes. (2)

The relationship between maternal dietary intake and the milk fat concentration is an important element in understanding the role of breast milk in infant nutrition. The quality of human milk secreted by the mother affects the infant development.

Abbreviations used: short chain polyunsaturated fatty acids,SC-PUFA;long-chain polyunsaturated fatty acids,LC-PUFA; α-Linolenic acid ,ALA;Linoleic acid,LA;eicosapentaenoic acid ,EPA;docosahexaenoic acid,DHA; arachidonic acid,AA/ARA; monounsaturated fatty acids, MUFA.

AIM OF THE REVIEW:

To summarize the available literature on the main sources of maternal dietary intake during pregnancy and lactation and its effect on fatty acids in human milk.

MATERIALS AND METHODS

Inclusion criteria:

1. Exposure variable: Among mothers, fatty acid profiles of breast milk, fatty acid profiles of maternal plasma and erythrocytes, their dietary intake, plasma levels and breast milk composition of iron and zinc.

2. Exposure variable: Among infants, fatty acid profiles of infant plasma and erythrocytes.

3. Measurements should be cross-sectional, or in the case of cohort studies, must have been carried out in the same individuals at baseline and at follow-up.

4. Intervention studies, for example, studies where the participants were part of any health promotion intervention.

Exclusion criteria:

1. Studies on animals.

2. Reviews or systematic reviews, rather than original data.

3. Meeting abstracts, posters, letters or commentaries.

DATA EXTRACTION AND ANALYSES

Data relating to the population characteristics, exposure and outcome variables were extracted (Table 1).The results of the studies were not combined in a meta-analysis due to considerable heterogeneity of the methodologies and analyses presented by different authors.

RESEARCH METHODOLOGY

Computerized literature searches were performed on CINHAL, ProQuest Central, j gate plus.in databases to locate all the articles on maternal nutrition during lactation and its effect on various constituents of human milk. Supply of fatty acids during antenatal period, first six months of exclusive breast feeding and beyond when mixed diet is offered to an infant influences neurological development. It's difficult to split the effects of fatty acid supply on neurodevelopment during gestation and infancy period. This further complicates the assessment of fatty acids from human milk or weaning diet impacting neurological development of an infant. Fatty acids in human milk vary on the basis of maternal fatty acids dietary intake. This paper concentrates on recent studies addressing maternal dietary intake of fatty acids and fatty acid levels in human milk as well as in infant's plasma. (1)

REVIEW WAS CONDUCTED ON FOLLOWING STUDIES:

1. Maternal dietary intake and essential fatty acids (EFA) in human milk (5 studies)
2. Maternal dietary intake and Vitamin A in human milk (2 studies)
3. Maternal diet and Vitamin D in human milk (2 studies)
4. Maternal dietary fish intake and DHA levels DHA levels vitamins in human milk (1 studies)
5. Maternal dietary supplementation of DHA and DHA levels in human milk (3 studies)

Sr. No	Source	Author	No. of Participants	Methods/Tools	Intervention	Authors Conclusion
1)	The American Journal of Clinical Nutrition	Krasevec et al.,2002(3)	Cuban Mothers(n= 50) Exclusively breast-fed infants (n = 18) Not exclusively breast-fed infants (n = 15)	a) Assessment of fatty acid profiles of breast milk. b) Assessment of fatty acid profiles of maternal plasma and erythrocytes. c) Assessment of fatty acid profiles of infant plasma and erythrocytes.	At the time of the study, all Cubans received 227 g of a highfat fish, Trachurus mediterraneu every week through the ration system. Thus, all the subjects received this amount of fish before and during their pregnancies. While breast-feeding, they	Mothers had satisfactory levels of EFA in their breast milk, plasma, and erythrocytes. The docosahexaenoic acid (DHA) levels in breast milk consisted of 0.43±0.26% of total fatty acids. The dietary supply of DHA to the breastfed infants seemed to be sufficient, as observed by the mean plasma and erythrocyte DHA

Sr. No	Source	Author	No. of Participants	Methods/Tools	Intervention	Authors Conclusion
					received a greater quantity of the same fish (454 g/wk.).	concentrations (2.82±0.84% and 7.41±1.16% of total fatty acids, respectively). Term infants' 2-mo-old were tested for visual acuity. The results had a mean of 2.00 ± 0.68 cycles/degree, which is within normal range. The results revealed that no relationship exist between EFA concentrations and visual acuity.
2)	European Journal of Nutrition	Antonakou A et al.,2013 (4)	Greek women : 1st month postpartum n = 64 3rd month postpartum n = 39 6th month postpartum n = 24	Cross-sectional study. Milk samples and dietary records were obtained of mothers at 1st (n = 64), 3rd (n = 39), and 6th (n = 24) month postpartum. Fatty acid methylesters were separated and quantified by gas chromatography (GC/FID) and fat concentration by the creamatocrit method.	-	During the first month postpartum, there was a significant positive association between mother's PUFA intake and the proportion of PUFA, ω 3 fatty acids, DHA, and LA in the milk, .There was a strong correlation ship of MUFA with PUFA, ω 6 fatty acids, and LA values. These findings support that diet consumed by Greek women had an effect on the composition of fatty acids in human milk during the first 6 months of exclusive lactation. Their diet consisted of high total, low saturated and high monounsaturated fat intake.
3	Annals of Nutrition & Metabolism	Olafsdottir et al.,2001(5)	Lactating mothers Control group=59 Experimental group = 16	a) Dietary intake of mothers calculated by 24 hours dietary recall. b) Breast milk samples for measuring fat soluble vitamins.	Supplementation of cod liver oil to the experimental group.	Supplementation of cod liver oil is sufficient to provide the recommended dietary intake of fat soluble vitamins for lactating women

Sr. No	Source	Author	No. of Participants	Methods/Tools	Intervention	Authors Conclusion
						than diet alone. In normal breast feeding infants, Vitamin D in human milk does not meet the recommended requirements for infants. Maternal diet correlates with Vitamin A and E in human milk.
4	British Journal of Nutrition	Yakes et al.,2011(6)	Out of 474 mothers of children from 24-48 months; 200 were non breastfeeding mothers and 274 were breast feeding mothers.	Cross-sectional multi-stage sampling	-	Breast milk of Bangladeshi mothers having children between 24– 48 months showed presence of easily absorbed medium-chain SFA, some LA and ALA, and satisfactory amounts of ARA and DHA. If, prolonged lactation with very low fat intake continues, maternal body pool of fatty acids would be used to meet the FA levels in human milk. Thus, increasing the dietary intake of PUFA in these mothers may positively influence composition of FA in breast milk and simultaneously health of their children.
5	European Journal of Clinical Nutrition	Bahrami, G., & Rahimi, Z. 2005(7)	52 lactating mothers aging 19–39y, from Western Iran.	Observational study. A diet questionnaire and milk samples were obtained from the mothers. High-performance liquid chromatography was used to measure fatty acids in human milk.	-	High levels of medium-chain and trans fatty acids were found in the milk from Iranian lactating mothers, in contrast with the American or European mothers. This variation of FA in human milk is highly contributed to the diet of Iranian mothers. Their diet

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						predominantly consists of low animal protein and animal fat but high carbohydrate and partially hydrogenated vegetable oils that carry large amounts of trans fatty acids. Trans fatty acids have detrimental effects on blood lipids and cardiovascular diseases .The study findings suggest that Iranian mothers should consume less amount of trans fatty acids in their diet.
6	European Journal of Nutrition & Food Safety	Bekele et al.,2015 (8)	Lactating mothers having infants from 6-12 months.	Community-based cross sectional data were collected from April to May 2012. Assessment of plasma levels and breast milk composition of iron, zinc, and retinol was done. To determine any association between plasma levels and micronutrients in breast milk Pearson's correlation were executed.	The prevalence of anemia (Hb< 120 g/L), zinc deficiency (plasma zinc < 0.7 mg/L), and vitamin A deficiency (plasma retinol ≤ 30 µg/dL) was 36%, 100% and 7.3%, respectively. There was on relationship of breast milk iron (0.24±0.1 mg/L) and breast milk zinc (0.08±0.06 mg/L) with plasma levels. The breast milk retinol (128.6±22.0 µg/L) was significantly associated with plasma retinol levels ($r=0.22$, $p<0.05$).	Low levels of vitamin A in human milk is highly contributed to the low vitamin A status in maternal plasma. If quality of complementary food is poor, low vitamin A in human milk may have unfavorable effects on children.

Sr. No	Source	Author	No. of Participants	Methods/Tools	Intervention	Authors Conclusion
7	Proceedings of the Nutrition Society	Zhang et al.,2012 (9)	108 women,	Expressed breast milk samples were collected at 2–3 weeks postpartum. Vitamin D2, D 3 and 25(OH) D were quantified using HPLC. Fat creamatocrit (v/v, %) of human milk was measured using a micro-haematocrit	-	The total vitamin D content in human milk is largely determined by the vitamin D3 content, which is associated with milk fat composition and maternal s25(OH)D concentrations, and negatively associated with the duration of lactation
8	European Journal of Nutrition	Martine F et al., 2012(10)		Descriptive comparative study	3 Tanzanian tribes with low (Maasai: 0/week), intermediate (Pare: 2–3/week), and high (Sengerema: 4–5/week) fish intakes. DHA and arachidonic acid (AA) were determined in maternal (m) and infant (i) erythrocytes (RBC) during pregnancy (1st trimester n = 14, 2nd = 103, 3rd = 88), and in mother–infant pairs at delivery (n = 63) and at 3 months postpartum (n = 104).	From delivery to 3 months postpartum, there was increase in maternal RBC-AA , while infant RBC-AA decreased. Maternal and infant RBC-DHA were higher in the sequence Sengerema (high fish)[Pare (intermediate fish)[Maasai (low fish). In contrast to RBC-AA, maternal and infant RBC-DHA were intimately related. Biomagnification of DHA occurred up to a maternal RBC-DHA of 5.6 g% at delivery; from this turning point, DHA became ‘‘bioattenuated’’. From delivery to 3 months postpartum, maternal RBC-DHA decreased, while infant RBC-DHA decreased in Maasai (low fish), remained constant in Pare (intermediate fish), and increased in Sengerema (high fish).

Sr. No	Source	Author	No. of Participants	Methods/Tools	Intervention	Authors Conclusion
9	The American Journal of Clinical Nutrition	Jensen et al.,2000(11)	Twenty-four pregnant women who planned to breast-feed exclusively for ≥8 wks, were recruited during the last trimester of pregnancy or at the time of delivery and were randomly assigned to 1 of 4 groups. (n = 6 mothers and infant pairs for each group)	Plasma and breast-milk fatty acids of mothers.	Supplementation of DHA in form of: a)Group 1 (algal DHA) b)Group 2 (eggs) c)Group 3 (fish oil) d)Group 4 (control)	Supplementation of lactating women with DHA (Docosahexaenoic acid) seems to be the most reliable means of increasing breast-milk DHA.
10	The Journal of Nutrition	Imhoff-Kunsch,et al.,2011(12)	174 mothers	A double blind randomized trial.	Daily supplementation of algae derived 400mg DHA or placebo from gestation 18-22wk to parturition on breast milk fatty acid parturition 1 month postpartum.	Prenatal DHA (Docosahexaenoic acid) supplementation from 18-22wk gestation to parturition increased concentration of DHA and ALA (α-linolenic acid) in breast milk at 1 month postpartum, providing a mechanism through which breast fed infants could benefit.
11	The Journal of Nutrition	Marc I et al.,2011(13)	a) Mothers who delivered ≤ 29 wk gestation, planned to breastfeed their preterm infants and received supplementation of DHA until 36 wks after conception. b) Preterm infants of these mothers. Experimental group (dyad of mother and preterm infant)=10 Control group(dyad of mother and preterm infant)=22	Longitudinal study	Mothers who delivered ≤ 29 wk gestation, planned to breastfeed their preterm infants and received supplementation of DHA (1200 mg/day) until 36 wks after conception.	Early supplementation with DHA to lactating mothers with low dietary DHA intake successfully increased the plasma DHA status in very preterm infants.

RESULTS:

Description of the included studies. A total of 11 studies fulfilled the selection criteria, and a summary of the characteristics and result of each study is presented in Table 1.Data were collected in Cuba, Greece, Iceland, Bangladesh, Iran, Ethiopia, Ireland, Tanzania, Atlanta, US, Mexico and Canada. The studies were published from 2000 to 2013.The samples consisted of pregnant mothers, post-partum mothers and their infants. In the review conducted the different variables measured among the mothers were fatty acid levels in their milk, fatty acid levels in maternal plasma and erythrocytes, characteristics of dietary intake and breast milk composition of iron and zinc. The different variables measured among the infants were, fatty acid levels in plasma and erythrocytes.

a) Essential Fatty Acids

Greek women diet consisted of high total, low saturated and high monounsaturated fat intake. The essential fatty acids were higher in breast milk of Greek women and in their infants as compared to those mothers and infants who consumed western diets. The findings show that diet influences composition of fatty acids in human milk during the first important 6 months of exclusive lactation. Maternal PUFA and MUFA intake were among the main FA affecting breast milk's FA profile. (4) Maternal body pool of fatty acids would be utilized to meet the needs of FA in human milk if lactation is prolonged combined with very low fat dietary intake.(6) Supplementation of cod liver oil to the diet of lactating women adequately meets the recommended intake of fat soluble vitamins for them than diet alone.(5) High levels of medium-chain and trans fatty acids in the milk from Iranian lactating mothers could be attributed to their diet consisting of low animal protein and animal fat but high carbohydrate and partially hydrogenated vegetable oils that carry large amounts of trans fatty acids. Reducing intake of trans fatty acids was suggested for these mothers (7).

b) Fat Soluble Vitamins A, D &E

The recommended intake of fat soluble vitamins for lactating women can more easily be met with a cod liver oil supplementation than diet alone. (5) Only Vitamin D in human milk cannot meet the recommended intakes for infants with normal breast feeding. (3)(5) Dietary intake of Vitamin A and E among mothers is significantly related to the levels of Vitamin A and E in human milk (5).

c) DHA

To improve breastmilk DHA is highly significant as it is the only food infants have for first six months. (11)Supplementation of DHA to mothers prenatally and during parturition who plan to breastfeed their infants is one of the most reliable means to increase breastmilk DHA (12).Supplementation of DHA to lactating mothers also increases plasma DHA in their preterm infants (13).

CONCLUSION

Maternal Dietary intake of vitamin A, DHA positively influences its level in human milk. Supplementation of DHA in prenatal and postnatal mothers increases DHA levels in milk for both preterm and term infants.

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