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Docosahexaenoic Acid and Arachidonic Acid Levels Among Indian Mothers: What Are the Implications?

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Abstract

Introduction: Dietary intake of docosahexaenoic acid (DHA) and arachidonic acid (ARA) is typically low in the Indian diet, leading to lower DHA and ARA levels in mothers. The aim of this study is to assess the levels of these fatty acids among Indian mothers. Material and methods: This case-control pilot study was conducted among 15 pregnant and five nonpregnant women who visited the gynaecology outpatient clinic of Cloud Nine Hospital, Bangalore, India between August 2018 and September 2018. All healthy pregnant and nonpregnant women willing to participate were included in the study. Blood samples were collected on special filter papers supplied by a laboratory based in Adelaide, Australia. All fatty acid profiles were analyzed using the Direct Cook method. Results: Levels of total trans-fatty acids, total omega-3 fatty acids (such as docosapentaenoic acid [DPA] and DHA), and omega-6 fatty acids (such as ARA) levels were found to be considerably lower among pregnant and nonpregnant women compared to the reference range. Furthermore, the levels of total omega-3 fatty acids (including eicosapentaenoic acid [EPA] and DPA), total omega-6 fatty acids (including linolenic acid [LA] and ARA), and trans-fatty acids were found to be lower among pregnant women when compared to nonpregnant women. Differences were statistically nonsignificant, except for DPA (p=0.0386). Conclusion: The present study found decreased levels of DHA and ARA among pregnant women compared to the standard reference range. Hence, the authors suggest the need for supplementation among mothers to increase the levels of these fatty acids and to improve health outcomes among infants, including preterm infants.

Keywords: Fatty acids, Docosahexaenoic acid, Arachidonic acid, India, Pregnancy, Supplementation

INTRODUCTION

In recent years, dietary guidance has universally recommended reducing the consumption of total and saturated fats, and replacing them with unsaturated fats, particularly from plant and marine sources. This change has been recommended, since saturated fats are believed to increase the risk of heart disease—creating a negative impact on the overall health of the population [1,2].

Fatty acids are essential constituents of the human body, having biological, structural, and functional roles [3]. They are essential for humans as well as other organisms. Fatty acids are important energy substrates and represent about 30%–35% of the total energy intake in humans. Fatty acids are classified as saturated and unsaturated fatty acids. Unsaturated fatty acids, particularly monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs), have shown protective effects on human health [3,4].

Omega-3 (n-3 fatty acids) and omega-6 (n-6 fatty acids) long-chain PUFAs (LCPUFAs) perform several important functions in the body, including influencing the inflammatory cascade, reducing oxidative stress, and conferring neuro- and cardiovascular protection [3]. Since these two essential fatty acids cannot be synthesized by the human body, they must be consumed through the diet [5]. In recent years, the effect of LCPUFAs on brain development and function has received considerable attention. Docosahexaenoic acid and ARA are

valuable members of the omega-3 and omega-6 fatty acid families and are found in the gray matter in the brain. Docosahexaenoic acid and ARA form the main constituents of the cellular membrane, and together account for up to 20% of the fatty acid content in the brain [6].

Docosahexaenoic acid (22:6[n-3]) is the major fatty acid in the brain responsible for signal transduction between neurons. Docosahexaenoic acid plays an essential role in myelination, gene expression, neuroinflammation, and neuronal differentiation and growth [7,8]. It is also a vital membrane component responsible for the development of the retina and proper vision. Dietary sources of DHA include seafood, fish, poultry, and eggs; however, sources such as vegetable fats, oils, grains, nuts, and seeds do not contain DHA. Arachidonic acid is an omega-6 (20:4n-6) fatty acid present in large quantities in the brain. The functions of ARA mainly include neuronal firing, signaling, and long-term potentiation. It is found in red meat, chicken, eggs, and human milk [8].

At the time of pregnancy, DHA accumulation in the fetal brain takes place mainly during the last trimester and continues to increase rapidly till two years postpartum [8,9]. It is estimated that the human foetus accrues about 67 mg of DHA/day from the mother, and that during lactation, the need increases to 70–80 mg/day. This huge demand for DHA, particularly during lactation, increases the concentration of DHA nearly 30 times during brain growth spurts, which begin during the third trimester of pregnancy and continue until 18 months [8]. Rapid accumulation of ARA takes place from the beginning of the third trimester of pregnancy up to about two years of age. Approximately 95 mg/day of ARA is accumulated by 30–40 weeks of gestation, which is nearly twofold higher vs. the corresponding rate for DHA [10].

The quantity and quality of dietary fats taken during pregnancy have a huge impact during and following pregnancy [11]. Adequate intake of omega-3 and omega-6 fatty acids is important for fetal growth and development [12]. Higher intake of fatty acids, especially omega-3 fatty acids, during pregnancy may be related to reduced intrauterine growth retardation, reduced depression in mothers, reduced allergies/asthma, reduced risk of preterm birth, and improved cognitive outcomes in offspring [13]. In a country like India, these benefits far outweigh any other aspect. Also, Indian women are thought to have low DHA levels in their blood [14].

Although both DHA and ARA have several benefits for maternal and fetal health, the typical Indian diet provides very low levels of these fatty acids [14,15]. Based on a literature review by Huffman et al., pregnant Indian women have a much lower intake of DHA compared to pregnant women from other developing countries [15]. In a prospective cohort study by Muthayya et al., DHA and ARA intake in South Indian pregnant women was about 11 and 33 mg, respectively, during the third trimester [16]. Studies comparing Bangladeshi pregnant women with Indian pregnant women found that Indian women had lower DHA intake despite consuming more fats. Interestingly, Bangladeshi pregnant women, who consumed around 11% of fats through the diet, had a DHA intake of 30 mg. By contrast, Indian women, who consumed about 25% of fats through the diet, had a DHA intake of merely 11 mg [15]. Another prospective cohort study conducted among South Indian pregnant women reported higher median intakes of LA during pregnancy (14.6 g/day), but low intakes of ALA, EPA, and DHA (0.56, 0.003, and 0.011 g/day, respectively) [14]. Low intakes of DHA and ARA among pregnant Indian women could be related to poor dietary intake during pregnancy [8].

Even though DHA and ARA have shown beneficial effects on maternal and fetal health, the intake of these fatty acids in the Indian diet is typically low. This low intake of DHA and ARA in the diet may lead to lower levels of these acids in mothers. The objective of the study is to assess the levels of DHA and ARA in Indian mothers.

MATERIALS AND METHODS

Female participants visiting the gynaecology outpatient clinic of Cloud Nine Hospital, Jayanagar, Bangalore, India between August and September 2018 were recruited for the study. All healthy pregnant (with no complications such as gestation diabetes mellitus [GDM] or hypertension) and nonpregnant women (age range: 20–40 years) willing to participate and provide their consent were included in the study. The participants were a random sample and consumed their usual diet. Women with chronic illnesses and those who declined consent to participate were excluded. Informed consent was obtained from all the participants. The study protocol was approved by the Ethics Committee. Blood samples were collected from all enrolled pregnant and nonpregnant women on special filter papers supplied by a laboratory based in Adelaide, Australia. Samples were sent to the laboratory via courier for further analysis.

All fatty acid profiles, including total saturated fatty acids, total trans-fatty acids, total monounsaturated fatty acids, omega-9, omega-7, omega-3 (18:3n-3 [ALA], 20:5n-3 [EPA], 22:5n-3 [DPA], and 22:6n-3 [DHA]), and omega-6 (18:2n-6 [LA] and 20:4n-6 [ARA]) fatty acids, were analyzed using the Direct Cook method. Samples were directly methylated and run on gas chromatography. These analytes were measured in %w/w (5th–95th percentile range) and converted as mean values (mean ± standard deviation [SD]) for each group. The diagnostic cut-offs for all fatty acid parameters, calculated as %w/w, are provided in Table 1.[17]

Table 1: Fatty acid profiles and their reference range (%w/w) [CSPA) Accreditation. 2012] [17]

Fatty acid profile	Reference range (5th–95th percentile, %w/w)
Total saturated fatty acids	36.66–41.14
Total trans-fatty acids	0.98–2.33
Total monounsaturated fatty acids	13.88–20.35
Total omega-3 fatty acids	4.32–11.54
Alpha-linolenic acid (ALA, 18:3n-3)	0.15–0.57
Eicosapentaenoic acid (EPA, 20:5n-3)	0.3–2.66
Docosapentaenoic acid (DPA, 22:5n-3)	1.23–2.65
Docosahexaenoic acid (DHA, 22:6n-3)	2.02–6.28
Total omega-6 fatty acids	30.48–40.23
Linoleic acid (LA, 18:2n-6)	12.74–21.97
Arachidonic acid (ARA, 20:4n-6)	9.95–16.9

The student's t-test was used for comparisons between the pregnant and nonpregnant groups. All statistical analyses were performed using Microsoft Excel (Microsoft Office 2016, Microsoft Corporation, USA); significance was defined as 0.05 level of confidence.

RESULT

Twenty women aged 20–40 years participated in the study, of whom 15 were pregnant (10 vegetarian and five nonvegetarian) and five nonpregnant. Table 2 provides the demographic details of all the 20 women who participated in the study.

Table 2: Demographic details of study participants

Total population; n (%)	20 (100%)
Age (years)	20–40 years
Pregnant women, n (%)	15 (75%)
Vegetarian, n (%)	10 (66.7%)
Nonvegetarian, n (%)	5 (33.3%)
Nonpregnant women, n (%)	5 (25%)

Table 3 provides the results for the fatty acid parameters assessed in pregnant and nonpregnant women. Of all the fatty acid profiles analyzed, total trans-fatty acid, total omega-3 fatty acid (such as DPA and DHA), and omega-6 fatty acid (such as ARA) levels were found to be substantially lower among pregnant and nonpregnant women compared to the reference range.

Total omega-3 fatty acid levels (pregnant women: 2.42 ± 0.71, nonpregnant women: 2.66 ± 1.73), including EPA (pregnant women: 0.4 ± 0.14, nonpregnant women: 0.9) and DPA (pregnant women: 0.45 ± 0.15, nonpregnant women: 0.62 ± 0.13), were found to be lower among pregnant women vs. nonpregnant women. Similarly, total omega-6 fatty acid levels (pregnant women: 37.31 ± 2.83, nonpregnant women: 40.16 ± 2.61), including LA (pregnant women: 24.05 ± 2.17, nonpregnant women: 26.38 ± 2.47) and ARA (pregnant women: 8.91 ± 1.51, nonpregnant women: 9.74 ± 1.43), were found to be lower among pregnant women vs. nonpregnant women. Furthermore, trans-fatty acid levels were also reported to be lower among pregnant women (0.49 ± 0.14) vs. nonpregnant women (0.56 ± 0.13). The difference for all these parameters, however, was statistically nonsignificant, except for DPA, which demonstrated statistical significance in the two groups (p=0.0386).

DISCUSSION

This case-control study demonstrated that fatty acid parameters such as total trans-fatty acid, total omega-3 fatty acid (such as DPA and DHA), and omega-6 fatty acid (such as ARA) levels were considerably lower among pregnant and nonpregnant women when compared to the reference range. Furthermore, trans-fatty acid, omega-3 fatty acid (such as EPA and DPA), and total omega-6 fatty acid (such as LA and ARA) levels were found to be lower among pregnant women vs. nonpregnant women. The difference for all these parameters was, however, statistically nonsignificant, except for DPA, which was found to be significantly different in the two groups (p=0.03).

These findings are similar to those previously published: low levels of DHA and ARA were reported among pregnant Indian women as a result of poor dietary intake of these fatty acids (especially fish and certain essential oils) during pregnancy [14–16].

Maternal fatty acid nutrition determines fetal health outcomes. It has been noted that inadequate nutrient transfer from the mother to foetus through the placenta can affect fetal growth and overall development. Furthermore, the transfer of fatty acids to the fetus is not only determined based on the fatty acid intake of the mother but also based on various physiological processes that occur during gestation. Observational studies conducted among mothers found that the consumption of low amounts of fish during pregnancy had a negative impact on cognitive and behavioural development [18].

During pregnancy, fatty acids are transferred across the placenta and are available in breast milk, to fulfil their role in postnatal growth. However, low dietary intake of DHA in women during pregnancy may lead to lower levels of DHA in breast milk, causing high risk on overall growth and development in infants [18]. Globally, DHA and ARA levels have been reported to widely vary in breast milk. This is largely due to variations in the diet. Women who consumed more fish report a higher milk DHA content [8]. In a cross-sectional study conducted among American Indian women, the mean fat content of breast milk was 4.67 ± 1.9 g/dL, with a mean DHA percentage of milk fat of 0.097 ± 0.035%, which is lower than recommended (0.20%–0.4%). This low DHA content in breast milk was associated with a low dietary intake of DHA (median daily intake: 30 mg) [19]. Furthermore, in Chinese women, the milk concentration of DHA was reported to be 0.44% in pastoral regions, in comparison to 2.8% (high levels) found in marine regions [20]. In human milk, the levels of ARA, in comparison to DHA, are more stable, since most of the ARA comes from maternal stores of ARA, rather than from dietary LA [10].

Since poor dietary intake of DHA and ARA in Indian pregnant women leads to lower levels of these fatty acids in human milk, causing abnormalities in infants, supplementation of omega-3 and omega-6 fatty acids during pregnancy can be an effective strategy for improving fetal birth outcomes [8,16]. Several studies have demonstrated that maternal DHA supplementation during pregnancy or lactation is associated with an increase in the DHA status of the foetus/infant [21-24]. Helland et al., in a randomized, double-blind study, assessed whether supplementation of omega-3 fatty acids during pregnancy and lactation improved infant outcomes. It was reported that maternal supplementation with cod liver oil until three months post-delivery was associated with an increased concentration of infant umbilical plasma DHAM [21]. Judge et al., in a randomized, double-blinded, placebo-controlled trial, included 30 pregnant women who received either DHA-functional food or placebo. The results reported significant differences in mean

visual acuity scores between the DHA group

Table 3: Comparison of fatty acid parameters between pregnant and nonpregnant women

Fatty acid parameter	Samples	N	Mean ± SD	p-value
Total saturated fatty acids	Total	20	40.38 ± 1.77	0.1223
	C9-Jnr (nonpregnant)	5	39.18 ± 1.98	
	C9-Jnr (pregnant)	15	40.77 ± 1.56	
Total trans-fatty acids	Total	20	0.51 ± 0.14	0.1528
	C9-Jnr (nonpregnant)	5	0.56 ± 0.13	
	C9-Jnr (pregnant)	15	0.49 ± 0.14	
Total monounsaturated fatty acids	Total	20	18.6 ± 1.99	0.1916
	C9-Jnr (nonpregnant)	5	17.44 ± 1.68	
	C9-Jnr (pregnant)	15	18.98 ± 1.98	
Total omega-9	Total	20	15.54 ± 1.38	0.3488
	C9-Jnr (nonpregnant)	5	14.86 ± 1.06	
	C9-Jnr (pregnant)	15	15.76 ± 1.43	
Total omega-7	Total	20	2.82 ± 0.73	0.2044
	C9-Jnr (nonpregnant)	5	2.46 ± 0.53	
	C9-Jnr (pregnant)	15	2.94 ± 0.76	
Total omega-3	Total	20	2.48 ± 1.01	0.5765
	C9-Jnr (nonpregnant)	5	2.66 ± 1.73	
	C9-Jnr (pregnant)	15	2.42 ± 0.71	
18:3n-3 (ALA)	Total	19	0.16 ± 0.08	0.0974
	C9-Jnr (nonpregnant)	4	0.1 ± 0	
	C9-Jnr (pregnant)	15	0.17 ± 0.08	
20:5n-3 (EPA)	Total	3	0.57 ± 0.31	0.6026
	C9-Jnr (nonpregnant)	1	0.9	
	C9-Jnr (pregnant)	2	0.4 ± 0.14	
22:5n-3 (DPA)	Total	20	0.5 ± 0.16	0.0386
	C9-Jnr (nonpregnant)	5	0.62 ± 0.13	
	C9-Jnr (pregnant)	15	0.45 ± 0.15	
22:6n-3 (DHA)	Total	20	1.77 ± 0.69	0.4158
	C9-Jnr (nonpregnant)	5	1.76 ± 1.18	
	C9-Jnr (pregnant)	15	1.77 ± 0.5	
Total omega-6	Total	20	38.02 ± 2.99	0.1047
	C9-Jnr (nonpregnant)	5	40.16 ± 2.61	
	C9-Jnr (pregnant)	15	37.31 ± 2.83	
18:2n-6 (LA)	Total	20	24.63 ± 2.42	0.0893
	C9-Jnr (nonpregnant)	5	26.38 ± 2.47	
	C9-Jnr (pregnant)	15	24.05 ± 2.17	
20:4n-6 (ARA)	Total	20	9.12 ± 1.49	0.3277
	C9-Jnr (nonpregnant)	5	9.74 ± 1.43	
	C9-Jnr (pregnant)	15	8.91 ± 1.51	

ALA: Alpha-linolenic acid; ARA: Arachidonic acid; DHA: Docosahexaenoic acid; DPA: Docosapentaenoic acid; EPA: Eicosapentaenoic acid; LA: Linoleic acid; SD: Standard

and the placebo groups at four months of age, suggesting that DHA supplementation during pregnancy plays an essential role in the maturation of the visual system [22]. In a few other randomized, double-blinded, placebo-controlled trials, maternal DHA supplementation showed beneficial effects in problem-solving tasks at nine months [23]. with improved mental processing scores at four years of age [24]. Maternal DHA supplementation is also one of the factors that may improve preterm birth outcomes. A recent Cochrane review has suggested that maternal LCPUFA supplementation has the potential to reduce the incidence of preterm birth and also reduce the likelihood of mothers giving birth to low-birth–weight infants [25]. The Assessment of DHA on Reducing Early Preterm Birth (ADORE) trial is a randomized, double-blinded trial that is currently underway and is exploring the efficacy and safety of high- and low-dose DHA supplementation in mothers in reducing the rate of earliest preterm birth [26].

The present study was conducted to determine fatty acid levels, particularly DHA and ARA levels, in pregnant women; identify unmet nutrient needs; and check whether supplementation could be an effective strategy for addressing these nutrient requirements.

The present study had certain limitations. Twenty participants constitute a small sample size that may not be representative of the entire population. Although the dietary patterns of women were collected, there were no detailed analyses regarding the value of DHA in their diet; furthermore, there was an equal number of vegetarians and nonvegetarians, although nonvegetarian Indians mainly eat chicken and egg and not seafood. The most important limitation was the duration of the study. This study was conducted for a period of two weeks and could only assess fatty acids levels among Indian mothers, without further determining maternal or fetal health outcomes and whether supplementation could have been beneficial in this setting—considering the low levels of omega-3 and omega-6 fatty acids detected in these women. Hence, long-term studies with large sample sizes and proper follow-up should be conducted to address these gaps.

CONCLUSION

In conclusion, this case-control study observed considerably lower levels of DHA and ARA among pregnant and nonpregnant women in comparison to the reference range. Furthermore, compared to nonpregnant women, pregnant women had lower levels of DHA and ARA. The difference, however, was not statistically significant, expect for DPA. According to studies, low levels of DHA and ARA are linked to poor maternal dietary intake during pregnancy. A maternal diet containing inadequate amounts of DHA and ARA may lead to lower levels of these fatty acids in breast milk, causing low birth weight and other abnormalities in the growth and overall development of infants. The study stresses the need for supplementation among mothers, to increase the levels of these fatty acids and further help in improving the health outcomes of infants, including preterm infants. Due to the lack of long-term data, the authors suggest conducting long-term studies with large sample sizes to address these unmet needs.

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Conflict of Interest

None declared.

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