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Different intakes of n-3 fatty acids among pregnant women in 3 regions of China with contrasting dietary patterns are reflected in maternal but not in umbilical erythrocyte phosphatidylcholine fatty acid composition

Jian Zhang[a,b,c,*], Chunrong Wang[a], Yixiong Gao[a], Lixiang Li[a], Qingqing Man[a], Pengkun Song[a], Liping Meng[a], Zhen-Yu Du[e], Elizabeth A. Miles[d], Øvyind Lie[b], Philip C. Calder[d], Livar Frøyland[b,*]

[a] Institute of Nutrition and Food Safety, Chinese Center for Disease Control and Prevention, Beijing 100050, China
[b] National Institute of Nutrition and Seafood Research (NIFES), N-5817 Bergen, Norway
[c] Department of Biomedicine, University of Bergen, N-5009 Bergen, Norway
[d] Human Development and Health Academic Unit, Faculty of Medicine, University of Southampton, SO16 6YD Southampton, United Kingdom
[e] School of Life Science, East China Normal University, Shanghai 200241, China

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ABSTRACT

There is limited information regarding the intake and status of polyunsaturated fatty acids (PUFA) in Chinese pregnant women with different dietary patterns. We hypothesize that there will be significant differences in long chain n-3 and n-6 PUFA status in pregnant women from 3 regions of China (river/lake, coastal and inland). Dietary fatty acid intakes and fatty acid profiles in maternal and umbilical erythrocyte phosphatidylcholine (PC) were analyzed. The median daily intakes (mg) of eicosapentanoic acid and docosahexaenoic acid (DHA) in the coastal group (64.6 and 93.9, n = 42) were significantly higher than those in the river/lake group (27.9 and 41.8, n = 41) and the inland group (12.1 and 41.1, n = 40). Daily intake of arachidonic acid (AA) was highest (170.2 mg) in the inland group. The median DHA level (%) of maternal erythrocyte PC was comparable between river/lake and inland groups (5.7 vs. 5.6) while both were significantly lower than in coastal group (8.4). The median AA level (%) of maternal erythrocyte PC tended to be lower in the coastal group than in the inland group but the difference was not significant. The AA and DHA levels in umbilical erythrocyte PC were comparable among the 3 groups. In conclusion, differences in long chain n-3 PUFA intake between geographic regions, in particular in DHA, were reflected in differences in maternal erythrocyte PC DHA status but did not result in differences in umbilical erythrocyte PC.

Abbreviations: AA, arachidonic acid; ALA, α-linolenic acid; DHA, docosahexanoic acid; DPA, docosapentanoic acid; EPA, eicosapentanoic acid; FFQ, food frequency questionnaire; LA, linoleic acid; LC n-3 PUFA, long chain n-3 polyunsaturated fatty acids; MUFA, monounsaturated fatty acids; PC, phosphatidylcholine; SFA, saturated fatty acids.

* *Corresponding authors.* Jian Zhang is to be contacted at Tel.: +86 010 83132560; fax: +86 01083132021. Livar Frøyland. Tel.: +47 48185032; fax: +47 55905299.
E-mail addresses: zhjian6708@yahoo.com.cn (J. Zhang), Livar.Froyland@nifes.no (L. Frøyland).

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1. Introduction

The long chain polyunsaturated fatty acids (LCPUFA), arachidonic acid (AA; 20:4n-6) and docosahexanoic acid (DHA; 22:6n-3) are vital structural components in biomembranes. AA is widely distributed in high proportions in all cell membranes, while DHA is present in high concentrations in the central nervous system and accumulates during the third trimester prenatally and the first 2 years postpartum [1-3]. Clinical studies showed that adequate supply of DHA improves the early development of visual acuity and other indexes of neurodevelopment in premature infants, and supplemental DHA even results in higher visual and neurocognitive test scores in infants at 12 months of age [4,5]. However, food souce of long-chain n-3 polyunsaturated fatty acids (LC n-3 PUFA) are limited and the estimated intakes of eicosapentanoic acid (EPA; 20:5n-3), and DHA in most populations are lower than the levels recommended by many organizations.

Linoleic acid (LA; 18:2n-6) and α-linolenic acid (ALA; 18:3n-3), which are abundant in plant tissues and in many seeds, nuts, and vegetable oils are essential fatty acids and are the precursors of AA and DHA, respectively. Due to the competition for desaturatase and elongase enzymes which are common for the conversion of both LA and ALA to their longer chain, more unsaturated derivatives, dietary n-6 fatty acids can influence n-3 fatty acid metabolism and tissue concentrations and vice versa. Increased use of LA-rich food sources in the food chain and in food processing has led to a marked increase in LA intakes such that LA now represents ≈90% of PUFA in many diets [6]. Concerns over high LA intakes have been raised and have focused in part on the possible inhibition of ALA conversion to the biologically active LC n-3 PUFA, such as EPA and DHA [7,8]. Studies using stable isotopes to trace ALA metabolism, as well as dietary supplementation studies with ALA have revealed that the conversion of ALA to DHA is poor (<0.5%) in adult humans [8,9]. Therefore, intake of both LA and ALA may influence LC n-3 PUFA status.

During the past 20 years, with striking economic development, there have been marked changes in the Chinese diet, and one conspicuous change has been the significant increase in the use and consumption of vegetable oils. Results from the National Nutrition Survey in China showed that from 1992 to 2002, vegetable oil intake increased by 24.1% and 74.8% for urban and rural residents, respectively [10]. Since most edible oils are rich in n-6 PUFA, especially LA, and low in n-3 PUFA, this rapid transition may have altered the balance of the 2 PUFA families in the diet. A previous study indicated that similar to that in some developed countries, the median value for the ratio of n-6 to n-3 fatty acids in the Chinese diet was approximately 8:1 [11]. Aquafoods, especially fatty fish, are the richest dietary source of EPA and DHA. However, intake of aquafoods is limited in most inland areas and lean fish are largely consumed in river/lake and coastal areas [9]. Therefore the absolute intake of EPA and DHA is lower than the recommendations and the reported values from some developed countries [11,12].

The status of fatty acids in Chinese pregnant women has begun to be of concern in recent years [13]. In 2005, we undertook an investigation of the fatty acid status of pregnant women in 3 regions (coastal, river/lake, and inland) with contrasting dietary habits and showed a significant difference in maternal and cord plasma EPA and DHA levels across the 3 regions that were related to differences in fatty acid intake [14]. Another study by Peng et al concentrated on the LC n-3 PUFA status in pregnant women from a south coastal and a river/lake region in China and also confirmed that there existed regional differences in fatty acid composition of maternal and umbilical cord plasma phospholipids and that the differences were largely associated with diet [15].

A systematic review which included 34 randomized controlled trials and 7 before-after studies showed that plasma phospholipid DHA appears to be a good marker of DHA status in women [16]. However, the fatty acid profile in plasma and in erythrocytes reflects different aspects of LC n-3 PUFA status during pregnancy, and plasma phospholipid DHA may have some limitations with regard to reflecting fatty acid status in pregnant or lactating women. One study showed that in reponse to fish oil supplementation to heart transplant patients, plasma phopholipids showed greater increases in EPA and DHA and had more rapid washout of these fatty acids than seen in erythrocytes [17]. Another study suggested that fetal erythrocytes transfer 6 times more DHA to the fetus than does the plasma free fatty acid fraction [18]. The venous-arterial difference in erythrocyte DHA concentration suggests that erythrocytes may play a key role in supplying developing fetal tissues with DHA and that erythrocyte PUFA are a better index for monitoring long-term intake of n-3 fatty acids, while plasma phospholipids are more sensitive to short-term changes in the intake of omega-3 fatty acids.

The dietary pattern varies significantly among pregnant women from different regions in China [14,15] and leads to the differences in fatty acid intake, in particular, for n-3 LCPUFA [14,15]. We hypothesize that that there will be significant differences in long chain n-3 and n-6 PUFA status in pregnant women from 3 regions of China (river/lake, coastal, and inland). To test this hypothesis, a cross-sectional survey was carried out, focusing on intake of aquatic foods intake, and assessing the fatty acid composition of maternal and neonatal (umbilical) erythrocytes.

2. Subjects and methods

2.1. Subjects

Healthy women with an uncomplicated singleton pregnancy were recruited from local hospitals of Jurong county, Jiangusu province (river/lake region, n = 41), Rizhao county, Shandong province (coastal region, n = 42) and Xushui county, Hebei province (inland region, n = 40) between 18 and 22 weeks of gestation. The exclusion criteria were residency of less than 5 years, regular consumption of fatty acid supplements; hypertension; diabetes; or metabolic, renal, psychiatric, or neurological disease. Fasting maternal blood (7 mL) and demographic, clinical, nutritional, and obstetric data were collected from the mothers at gestation week 34, and umbilical cord blood (7 mL) and anthropometric information were collected from the babies at delivery. The study was approved by the Ethics Committee of the Institute of