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Fatty acid status and antioxidant defense system in mothers and their newborns after salmon intake during late pregnancy

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ABSTRACT

Objective: The aim of the present study was to assess the maternal and newborn status of erythrocyte fatty acids and the antioxidant defense system after the intake of two portions of salmon per week during late pregnancy.
Methods: Pregnant women (N = 123) were randomly assigned to continue their habitual diet, which was low in oily fish (control group, n = 61) or to consume two 150-g salmon portions per week (salmon group, n = 62) beginning at 20 wk of gestation and lasting until delivery. Fatty acids, selenium, and glutathione concentrations and antioxidant defense enzyme activities were measured in maternal erythrocytes at 20, 34, and 38 wk of pregnancy, and in cord erythrocytes collected at birth. Plasma concentrations of antioxidant molecules were measured.
Results: Compared with the control group, consuming salmon had little effect on erythrocyte fatty acids in either mothers or newborns. Components of the antioxidant defense system did not differ between groups. Glutathione peroxidase activity and the concentrations of tocopherols, retinol, and coenzyme Q10 were significantly lower in cord blood compared with maternal blood at week 38 in both groups.
Conclusion: Maternal and newborn erythrocyte fatty acids are not strongly affected by the intake of two portions of salmon per week during the second half of pregnancy, although erythrocyte docosahexaenoic acid might be increased in newborns. Maternal and newborn antioxidant defense systems are not impaired by intake of salmon from 20 wk gestation.
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Introduction

The requirements for the long-chain polyunsaturated fatty acids (LC-PUFA) arachidonic acid (AA, C20:4 ω-6) and docosahexaenoic acid (DHA, C22:6 ω-3) are especially high during the last trimester of pregnancy and the first weeks of extrauterine life because of their accretion into the growing brain and other tissues [1,2]. AA and DHA can be formed by elongation and desaturation of the essential precursors linoleic acid (LA; C18:2 ω-6) and α-linolenic acid (ALA; C18:3 ω-3), respectively, but fetal fatty acid-desaturase enzymes are unable to supply sufficient LC-PUFA until 16 wk after birth [3]. Therefore, fetal LC-PUFA must be supplied from the maternal circulation and so are ultimately derived from the maternal diet.

The increased fetal demand for LC-PUFA is indicated by a concomitant decrease in the relative concentrations of DHA and AA in the maternal plasma as pregnancy progresses [4,5]. Fish oils rich in ω-3 LC-PUFA, DHA and eicosapentaenoic acid (EPA; 20:5 ω-3), may enhance maternal, fetal, and neonatal PUFA status. Findings from several studies have shown that dietary intakes of ω-3 LC-PUFA of ≥2.6 g/d significantly increase the ω-3 LC-PUFA status in both pregnant women and their newborns [6–8]. Nonetheless, this increase may be accompanied by a reduction of ω-6 LC-PUFA toward the end of pregnancy [8–11], and this is not desirable.

The UK government recommends that pregnant women consume one or two portions of oily fish each week as a source of ω-3 LC-PUFA [10]. It is not clear whether consumption of fish as a whole food delivering ω-3 LC-PUFA affects the ω-3 LC-PUFA status of mothers and their newborns. In this regard, one study observed higher EPA and DHA status and lower AA status in mothers with high dietary intake of oily fish in relation to those with lower consumption, with similar findings in newborns [11]. To our knowledge, no intervention studies apart from Salmon in Pregnancy Study (SiPS) [12] have investigated the effect of higher oily fish intake in pregnant women whose consumption of oily fish was normally low. In SiPS, the intake of two portions of salmon per week (equivalent to a daily intake of about 500 mg EPA + DHA) resulted in an enhanced plasma EPA and DHA status in pregnant women, and a higher EPA and DHA status in the umbilical cord blood plasma than seen in the control group [12].

It is known that LC-PUFAs are good substrates for lipid peroxidation, and so a diet high in ω-3 LC-PUFA could contribute to oxidative stress [13]. However, several mechanisms exist to protect against peroxidative damage. These mechanisms involve exogenous vitamins and trace elements as well as endogenous enzyme systems [14]. In SiPS, maternal oxidative stress markers remained unaffected after consumption of two portions of salmon per week [15]. Furthermore, maternal retinol and selenium (Se) levels were significantly higher in the group supplemented with salmon than in the control group [16]. To our knowledge, there are no studies on the effect of increased maternal oily fish intake on the antioxidant defense system in newborns.

Therefore, the aims of the present study, as part of SiPS, were to examine the effect of increased salmon consumption beginning in week 20 of pregnancy through delivery (1) on erythrocyte fatty acids in pregnant women and their newborns and (2) on the antioxidant defense system in the newborns' blood.

Materials and methods

The study design, characteristics of the pregnant women, aspects of their diet, and compliance have been described in detail elsewhere [12]. In brief, 123 pregnant women residing in or near Southampton, United Kingdom were enrolled in the study. The inclusion criteria were age 18 to 40 y; <19 wk gestation; healthy, uncomplicated, singleton pregnancy; having a baby at risk for atopy; consuming less than two portions of oily fish per month, excluding tinned tuna; and not taking fish oil supplements either currently or in the previous 3 mo. The Southampton and South West Hampshire Research Ethics Committee (07/Q1704/43) approved all procedures. The study was conducted according to the principles of the Declaration of Helsinki, and all the women provided written informed consent. SiPS is registered at www.clinicaltrials.gov (NCT00801502).

Study design

We randomly assigned the women to one of two groups. Women in the control group (n = 61) were asked to continue their habitual diet, whereas those in the salmon group (n = 62) were asked to incorporate two portions of farmed salmon per week (150 g/portion) into their diet from study entry (20 wk of pregnancy) until delivery. SiPS was powered according to an anticipated increase in maternal plasma phosphatidylcholine EPA content. It was calculated that a sample size of 50 women per group would have 93% power to detect a 50% higher plasma phosphatidylcholine EPA content in the salmon group than in the control group [12]. The farmed salmon used in the SiPS were raised at Skretting Aquaculture Research Centre (Stavanger, Norway), using dietary ingredients selected to contain low levels of contaminants. Each 150-g salmon portion contained (on average) 30.5 g protein, 16.4 g fat, 0.57 g EPA, 0.35 g docosapentaenoic acid (DPA, C22:5 ω-3), 1.16 g DHA, 3.56 g total ω-3 PUFA, 4.1 mg α-tocopherol, 1.6 mg γ-tocopherol, 6 μg vitamin A, 14 μg vitamin D_3, and 43 μg selenium. The full fatty acid composition of the salmon is shown in Table 1. Contaminants constituted <12.5% of the Food and Agriculture Organization/World Health Organization provisional tolerable weekly intake for dioxin and dioxin-like polychlorobiphenyls, <11.5% for arsenic, <0.00000008% for cadmium, 0.0000025% for mercury, and <0.00000002% for lead [12].

Fifteen women were unable to complete the study as a result of preterm delivery, withdrawal due to fatigue, a busy schedule, or an unspecified injury, leaving 54 women in each group at the end of the study; 101 blood samples were collected at birth (50 from the control group and 51 from the salmon group) [12].

Analytical procedures

Fasting maternal venous blood samples were collected for analysis at 20 wk of gestation (before the intervention started), at 34 wk, and at 38 wk. Blood samples were obtained from the umbilical vein after cord clamping, immediately after delivery. All samples were added to heparin and centrifuged. Plasma and washed erythrocytes were immediately frozen and stored at −80°C.

Erythrocyte fatty acid profile

Erythrocyte fatty acids were transmethylated using acetyl chloride [17]. Hexane-resuspended methylated fatty acids were injected into a Hewlett Packard HP5890 Series II chromatograph (Hewlett Packard, Palo Alto, CA, USA), with a capillary column (60 m × 32 mm inner diameter; 20 μm film thickness) impregnated with SP2330 FS (Supelco, Bellefonte, CA, USA). Running conditions were as described elsewhere [18]. Fatty acid methyl esters were identified by comparison of retention times with those of authentic standards run previously.

Table 1
Fatty acid composition of the salmon

Fatty acid	Percentage of salmon fatty acids
Myristic acid (14:0)	2.25 ± 0.09
Palmitic acid (16:0)	12.25 ± 0.27
Palmitoleic acid (16:1 ω-7)	2.52 ± 0.08
Stearic acid (18:0)	3.32 ± 0.11
Oleic acid (18:1 ω-9)	33.01 ± 0.36
Vaccenic acid (18:1 ω-7)	2.70 ± 0.01
Linoleic acid (18:2 ω-6)	11.60 ± 0.15
α-Linolenic acid (18:3 ω-3)	7.37 ± 0.32
Eicosenoic acid (20:1 ω-9)	2.79 ± 0.13
Docosadienoic acid (20:2 ω-6)	1.15 ± 0.2
AA (20:4 ω-6)	1.30 ± 0.05
EPA (20:5 n-3)	3.53 ± 0.16
Nervonic acid (24:1 ω-9)	0.36 ± 0.01
DPA (22:5 ω-3)	2.09 ± 0.04
DHA (22:6 ω-3)	7.11 ± 0.11
Others	6.65 ± 0.04

AA, arachidonic acid; DHA, docosahexaenoic acid; DPA, docosapentaenoic acid; EPA, eicosapentaenoic acid

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