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Validity of a food frequency questionnaire to estimate long-chain polyunsaturated fatty acid intake among Japanese women in early and late pregnancy

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ABSTRACT

Background: The relative validity of food frequency questionnaires for estimating long-chain polyunsaturated fatty acid (LC-PUFA) intake among pregnant Japanese women is currently unclear. The aim of this study was to verify the external validity of a food frequency questionnaire, originally developed for non-pregnant adults, to assess the dietary intake of LC-PUFA using dietary records and serum phospholipid levels among Japanese women in early and late pregnancy.
Methods: A validation study involving 188 participants in early pregnancy and 169 participants in late pregnancy was conducted. Intake LC-PUFA was estimated using a food frequency questionnaire and evaluated using a 3-day dietary record and serum phospholipid concentrations in both early and late pregnancy.
Results: The food frequency questionnaire provided estimates of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) intake with higher precision than dietary records in both early and late pregnancy. Significant correlations were observed for LC-PUFA intake estimated using dietary records in both early and late pregnancy, particularly for EPA and DHA (correlation coefficients ranged from 0.34 to 0.40, $p < 0.0001$). Similarly, high correlations for EPA and DHA in serum phospholipid composition were also observed in both early and late pregnancy (correlation coefficients ranged 0.27 to 0.34, $p < 0.0001$).
Conclusions: Our findings suggest that the food frequency questionnaire, which was originally designed for non-pregnant adults and was evaluated in this study against dietary records and biological markers, has good validity for assessing LC-PUFA intake, especially EPA and DHA intake, among Japanese women in early and late pregnancy.

1. Introduction

Essential fatty acids, especially their long-chain polyunsaturated derivatives, are primary structural components of cell membranes. Increasing evidence suggests that long-chain polyunsaturated fatty acids (LC-PUFAs) may be important in fetal development and the accretion of maternal, placental, and fetal tissue.[1–4] In particular, n-3 polyunsaturated fatty acids (PUFAs), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), comprise the major structural fat of the human brain and eyes.[5–7] The Japanese diet is rich in n-3 PUFAs due to a high consumption of seafood, and the epidemiological benefits of these fatty acids have been widely reported.[8–11]

Food frequency questionnaires (FFQs) are useful for assessing dietary habits and quantitatively estimating usual food consumption over a fixed period of time. However, like all dietary methods, estimated nutrients derived from FFQs suffer from random and systematic error and may not accurately reflect usual food intake.[12]

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Therefore, it is essential to validate FFQs because inaccurate information may give rise to misleading associations between dietary factors and diseases.

The relative validity of the FFQ for assessing LC-PUFA intake in Japan has been previously reported.[13,14] However, a validation study of the FFQ for pregnant women is required, as pregnant women are likely to experience a change in dietary habits as well as appetite or to choose food that is different than their pre-pregnancy diet, which consequently changes their everyday dietary intake.[15,16]

Although plurality of dietary records (DR) is the most frequent reference method to validate FFQs, biomarkers that show a strong direct relationship with the nutrient of interest may also be used as a reference to validate the FFQ, as their measurement errors would be independent from those of dietary assessment methods.[17,18] For dietary EPA and DHA intake measured by FFQs, several previous studies have used EPA and DHA concentrations in the blood for validation.[19,20]

The aim of this study was to verify the external validity of an FFQ, which was originally developed for non-pregnant adults, to assess the dietary intake of LC-PUFAs using the dietary records and biomarkers of LC-PUFAs in serum phospholipid levels among women in early and late pregnancy.

2. Methods

2.1. Participants

A validation study of a FFQ was performed to estimate the dietary intake of LC-PUFAs in a selected subset of pregnant women conducted at the National Center for Child Health and Development (NCCHD) in Tokyo, Japan. Participants were enrolled at 5–15 weeks of gestation. Of the 248 women initially enrolled in the validation study, 60 were excluded in early pregnancy for the following reasons: withdrawal from the study (n = 21), inability to eat due to hyperemesis gravidarum (n = 2), missing FFQ data (n = 21), and incomplete dietary records (n = 16). Ultimately, 188 early-pregnancy participants completed both the 3-day dietary records and the FFQ at 5–15 weeks of gestation. Of these participants, 186 had a blood sample taken before the FFQ at 8–14 weeks of gestation. Of the 248 women initially enrolled, 79 women were excluded in late pregnancy for the following reasons: withdrawal from the study (n = 21), inability to eat due to hyperemesis gravidarum (n = 2), missing FFQ data (n = 50), and incomplete dietary records (n = 6). Ultimately, 169 late-pregnancy participants completed both the 3-day dietary records and the FFQ during late pregnancy at 26–35 weeks of gestation. Of these participants, 153 had a blood sample taken before the FFQ at 20–30 weeks of gestation. There were no substantial differences in baseline characteristics between the enrolled participants and the included participants (all $p > 0.2$).

2.2. Standard protocol approvals, registrations, and patient consent

Written informed consent was obtained from all participants at enrollment, and the Institutional Review Board at the NCCHD approved this study (Approval No. 467). The present study was conducted according to the guidelines of the Declaration of Helsinki.

2.3. Food frequency questionnaire (FFQ)

The FFQ included 167 food and beverage items. Respondents were asked to indicate their usual consumption for each item within the past 2 months using nine frequency categories, starting from almost never to seven or more times per day (or, for beverages, to 10 glasses per day). We modified the original version of the food list used in the Japan Public Health Center-based Prospective Study[21] by adding six foods and a beverage consumed in urban areas: ground meat, pastry, corn flakes, pudding, jelly, and cocktails. The list also included 20 items rich in n-3 PUFA, such as fish, shellfish, and other fish products. For each food and item, portion size was indicated by three standard sizes: small (50% smaller than usual), medium (the standard amount), and large (50% larger than usual). Energy and LC-PUFA intakes were calculated using a food composition table developed for the FFQ based on the Standardized Tables of Food Composition in Japan (2010 edition).[22]

2.4. Dietary records

Participants noted their food and beverage consumption in dietary records for 3 days in early pregnancy between 5 and 15 weeks of gestation, and for 3 days in late pregnancy between 26 and 35 weeks of gestation, before completion of the FFQ and following the protocol of the original validation study.[23] These records documented women's dietary intake over 2 weekdays and 1 weekend day, and were used as the reference method for this study. For each meal during these 3 days, participants were asked to measure all food portions using digital scales, measuring spoons, and cups and document all ingredients and preparation methods. Trained dietitians would then telephone each participant and verify the record, as well as code the foods and the amounts prepared. Energy and LC-PUFA intakes were calculated using the Standard Tables of Food Composition in Japan (2010 edition).[22]

2.5. Serum phospholipid levels

Non-fasting blood samples were obtained from each participant at enrollment and late pregnancy between 26 and 35 weeks of gestation. Blood samples were separated by centrifugation for 5 min at 3,000 rpm immediately after venipuncture and stored at −40 °C in the NCCHD's hospital laboratory. Samples were then packed with dry ice and carefully transported to an external laboratory for analysis (SRL. Inc., Hachioji, Tokyo, Japan). Serum phospholipids were extracted using chloroform-methanol (2:1 v/v) followed by acid hydrolysis. After being esterified in boron trifluoride-methanol, serum fatty acid composition was analyzed by gas chromatography using a Shimadzu model GC-2010 gas chromatograph (Shimadzu, Kyoto, Japan) equipped with column capillary polyethylene glycol Omegawax (30 m in length, 0.25 mm internal diameter, 0.25 μm film thickness,; Sigma-Aldrich Co. LLC, St. Louis, MO, USA). Concentrations of each fatty acid were expressed as a proportion of all serum fatty acids.

2.6. Statistical analysis

Paired *t*-tests were used to test the difference between FFQ and dietary record estimates of LC-PUFA intake for both early and late pregnancy. Spearman correlation coefficients were calculated between the FFQ and dietary record estimates or responsive LC-PUFA levels of serum phospholipids. The degree of misclassification across categories was examined between FFQ and dietary records or between FFQ and serum phospholipid levels by dividing LC-PUFA intake estimated from the FFQ into quintiles. Mean dietary record values or LC-PUFA composition in serum phospholipids were calculated and assigned to categories defined using the dietary records or serum phospholipid levels. An analysis of variance with a Tukey-Kramer post-hoc comparison of means was performed to test for differences between the lowest and highest quintiles. Trend tests were conducted by median for each category of intake. Statistical analyses were performed using SAS statistical software (version 9.4; SAS Institute Inc, Cary, NC, USA).