Original research

Patterns of fish consumption and levels of serum phospholipid very-long-chain omega-3 fatty acids in children with and without asthma, living in Perth, Western Australia


Abstract

Objective: To measure patterns of fish intake and to investigate the extent to which these may predict serum phospholipid levels of the very-long-chain (VLC) omega-3 fatty acids, eicosapentaenoic (EPA C20:5 omega-3) and docosahexaenoic (DHA C22:6 omega-3) acids in a sample of children.

Design: A subset within a nested case control study provided serum phospholipid samples for fatty acid analyses.

Setting: Perth, Western Australia.

Subjects: A nested case control study (n = 335) of eight-year-old children with (n = 166) and without asthma (n = 169) and blood samples for fatty acid analyses from a subset of these (n = 60).

Methods: Data on fish type and intake over the previous year were collected from parents on behalf of their children using the Commonwealth Scientific and Industrial Research Organisation (CSIRO) food frequency questionnaire. Fasting venous blood samples from the subset of children were analysed for fatty acids measured by gas liquid chromatography. Analysis of variance and Spearman’s correlation methods were applied in the analysis to determine associations between fish intake and serum VLC omega-3 fatty acids.

Main results: Fresh fish accounted for 33% of fish consumed once a week or more by children in the dietary study. The mean concentration of EPA and DHA in serum phospholipids increased significantly from the lowest to the highest fish consumption categories. There were significant correlations between frequency of fish intake as estimated by questionnaire and EPA, DHA, and EPA + DHA combined, as measured in the serum. No differences in serum VLC omega-3 fatty acids were evident in children with and without asthma.

Conclusions: In this sample, most children consumed fish at least once per week and the frequency of fish intake as measured by food frequency questionnaire was a valid predictor of EPA and DHA levels in serum phospholipids.

Key words: fish intake, omega-3 fatty acids, eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), biomarkers, children
Introduction

A diet rich in omega-3 polyunsaturated fatty acids is linked with a number of health benefits in adults, particularly for conditions where reduction of a chronic inflammatory response is involved (1). For children, there is evidence that long chain omega-3 fatty acids, particularly the very-long-chain (VLC) versions (20C and 22C) predominantly found in fish, are protective of asthma (2), a disease involving inflammation. To date, evidence for an association between asthma risk and particular dietary fatty acids has come from epidemiological studies, some of which have focussed on fish intake (2) or other specific fatty acids sources (3,4).

Despite the strong level of interest in the health benefits of omega-3 fatty acids, relatively little is known about the omega-3 fatty acid status of Australians, particularly children. Information about the status of a nutrient can be derived from dietary information on the intake of that nutrient or from biomarkers, which typically provide biochemical, or physiological information about the nutrient in the body. The latter are considered the gold standard but usually involve invasive and expensive testing. When dietary intake is used to provide information about nutrient status, it is important to be aware of the key sources of that nutrient, in relation to the population under study.

The very-long-chain omega-3 fatty acids are found predominantly in fish. An analysis of the 1995 National Nutrition Survey (NNS) indicated that seafood contributed 71% of the VLC omega-3 fatty acid, with meat and eggs contributing 20% and 6%, respectively (5). The dominance of fish as a source of VLC omega-3 fatty acids in Australia and elsewhere has resulted in several studies using frequency of fish consumption as a proxy for VLC omega-3 fatty acid intake (6). This approach is supported by the demonstration of a rectilinear relationship in adults between dietary intake of eicosapentaenoic (EPA) and docosahexaenoic acids (DHA) and a biomarker, the plasma phospholipid levels of these fatty acids (7). Limited investigation of the relationship between fish intake (frequency or amount) and serum levels of VLC omega-3 fatty acids in children has occurred when the prevalence of asthma in children is at its highest (8). A Finnish study of children and young adults reported a significant association between fish intake (g/1000 kcal) and plasma phospholipid levels of VLC omega-3 fatty acids in children to nine years of age (9). Therefore in the Finnish population, a relationship between intakes of fish, and thus VLC omega-3 fatty acids, and plasma levels extends to children.

The frequency of fish consumption of foods was determined using a food frequency questionnaire (FFQ) in our study. As with all methods used to monitor intake, food frequency questionnaires have their advantages and limitations (10). In our study, the use of a FFQ was advantageous in that it focussed on usual intake, could be administered by mail and minimised respondent burden. However, a FFQ relies on memory and the ability to relate actual consumption to description of portion sizes and estimates of frequency, both skills varying substantially between individuals (10). Specific limitations associated with using a FFQ for assessing intake of children are that an Australian FFQ has not been validated for use with children and serve sizes have remained the same as those used to estimate the intake of adults. It is not known to what extent parents take this into consideration when responding to how often a child consumes a food in the given serve size.

The adequacy of a FFQ to assess the intake of any particular nutrient depends on how well the questions are designed to capture information on key nutrient sources. None of the FFQs developed in Australia include questions specifically designed to estimate all current sources of omega-3 fatty acids. However the Commonwealth Scientific and Industrial Research Organisation (CSIRO) FFQ (11) used by Hodge et al. (2) included some questions relating to the type and frequency of fish consumption, as did the Melbourne FFQ (12) used by Woods et al. (13).

Canned fish is a richer source of VLC omega-3 fatty acids than most of the fresh fish available to Australians (14), thus frequency of consumption of any fish may not be sufficient to generate useful information about actual intake. No data were found regarding canned fish consumption by Australian children so it was not known if this was sufficient to affect the relationship between fish intake frequency and actual VLC omega-3 fatty acid intake.

Regardless of the choice of tool for estimating food intake, the conversion of information on food sources to nutrient intake relies on a database appropriate to the food supply under question. Recently a database has become available on the fatty acids composition of Australian foods, particularly omega-3 fatty acids (15). This has greatly expanded the omega-3 fatty acids data available as well as increasing the precision of previous data. The analysis presented in this paper was performed before the advent of the improved database, however that does not influence the investigation of the relationship between frequency of fish consumption and the VLC omega-3 fatty acid levels in serum phospholipids of children. On the other hand, our ability to confidently convert the frequency of fish consumption into intake of VLC omega-3 fatty acids is limited by the database and other aspects of the FFQs as discussed.

Thus the aims of this study were to describe patterns of fish consumption in eight-year-old children with and without asthma, and to investigate the extent to which the frequency and type of fish consumption would predict the serum phospholipid levels of the VLC omega-3 fatty acids. Given the current lack of information regarding VLC omega-3 fatty acid intake by Australian children, and the interest in fish intake and asthma risk, it is important to know if patterns of fish consumption are sufficient to predict serum phospholipid levels of these fatty acids and are thus a reliable proxy measure.

Methods

Subjects

The present nested case control study was a subset of the Western Australian Pregnancy Cohort Study (WAPCS) (16,17) in which dietary intake of children with asthma (n = 166 cases) and those without asthma (n = 169 controls) was investigated. Fasted blood samples for phospholipid fatty acid analyses were obtained from 60 subjects.
Participants in the case-control study

Case ascertainment

During 1999 when the children were eight years of age, we aimed to study all cases in the WAPCS of current asthma identified at six years. Children who had asthma were eligible and included in the study reported here as cases. Cases were children defined as having current asthma diagnosed by a doctor and wheeze in the last year, or using preventer or reliever medication, identified from the six-year assessment (n = 147). If a parent reported diagnosis of asthma by a doctor and wheeze in the last year or using asthma medication at age eight but not at age six, the child was included as a case (n = 19). If a parent reported that an identified case from the six-year follow-up no longer had asthma at age eight the child was excluded from the study. As a child had to meet the criteria for inclusion as a case, all suffered from either moderate or severe asthma. Mothers were telephoned, invited to participate and the child’s asthma status confirmed. Case children whose mothers consented to participate by telephone were sent dietary questionnaires.

Control ascertainment

Control subjects were children with no diagnosis of asthma, no current wheeze and not taking asthma medication at either six or eight years of age. At the same time as case ascertainment, controls were frequency matched (one per case) on gender and age (within one month). Only control subjects whose parent consented to participate were sent dietary questionnaires.

Study participants

Exposure to possible risk factors for asthma was unknown in both groups. We identified 190 eligible asthma cases and interviewed 147 parents (77%) by phone; 212 children eligible as controls were identified and 188 (89%) parents were interviewed. Of the 188 parents interviewed, 19 children were found to be asthma cases leaving a total of 169 controls. Thus there were 335 children (166 cases and 169 controls) selected, for whom complete eight-year clinical data were available (83% response rate).

Dietary data collection

Materials were posted to all participating parents and included an introductory letter, the dietary questionnaire, a contact phone number and a reply-paid envelope. The mailout took place two weeks after the eight-year clinical assessment of the Western Australian Pregnancy Cohort in which the blood sample was taken.

Dietary data were collected over nine months (March–December 1999). The study nurse checked the dietary questionnaire for completeness and re-contacted parents who had returned an incomplete questionnaire. Three follow-up phone calls were made to families who had not returned their questionnaire.

The CSIRO questionnaire was based on that semi-validated in adults (11) and previously applied in children (2). Data on the child’s usual diet over the past year as well as seasonal variation for vegetables, fruits, soups and desserts were collected. A parent completed the questionnaire on behalf of the study child in approxi- mately 20 minutes, as based on a pilot test of the questionnaire with three randomly selected parents.

Fish consumption and categories

A specific question about the child’s usual fish consumption and serve size was integral to the CSIRO questionnaire (Table 1). The options given for frequency of consumption were: never; rarely; 1, 2, 3 times a month; 1, 2, 3 times a week; 1, 2, 3 times a day. The frequency of fish consumption was subsequently categorised and analysed on the basis of: never or rarely; less than once a week; once to twice a week; more than twice a week.

In addition to the CSIRO question on usual intake we asked the fish type usually consumed. Children who ate any fish at least once a week provided details of the fish consumed.

The defined fish categories used in analysis were created from the question in Table 1. The defined fish categories were any fish; canned fish (including that used in mornays); fish (fried, steamed, boiled or grilled); seafood other than fish (prawns, crab, lobster etc) and fish fingers. Any fish consumption was a composite variable representing consumption of any of the fish categories given. Canned fish was a compilation variable representing any canned fish (such as tuna or salmon) or mornay dishes that used canned fish. Fried, steamed, boiled or grilled fish represented all other fish, except fish fingers. Seafood (prawns, crab or lobster), and fish fingers were stand-alone categories.

Dietary analysis

The database for composition of fatty acids in foods was developed using a range of databases by CSIRO, Adelaide, South Australia. Nutrient composition to develop and modify the database was derived from four sources:

<table>
<thead>
<tr>
<th>Table 1.</th>
<th>Question on fish consumption and serve sizes asked in the CSIRO® food frequency questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>About how often does your child usually eat these foods?</td>
<td>Serve size</td>
</tr>
<tr>
<td>Fish—fried (please state what type of fish)</td>
<td>1 piece or 6 nuggets</td>
</tr>
<tr>
<td>Fish without batter (steamed, grilled/boiled) (please state what type of fish)</td>
<td>1 piece</td>
</tr>
<tr>
<td>Canned fish (tuna, salmon etc.)</td>
<td>1/3 cup</td>
</tr>
<tr>
<td>Fish fingers</td>
<td>3–4 fingers</td>
</tr>
<tr>
<td>Seafood (prawns, crab, lobster etc)</td>
<td>½ cup</td>
</tr>
<tr>
<td>Mornay dishes</td>
<td>1 cup</td>
</tr>
</tbody>
</table>

(a) CSIRO: Commonwealth Science and Industry Research Organisation.
1. Australian nutrient databases (18,19);
2. British food tables (20);
3. US Dept of Agriculture (USDA) food tables (21); and
4. Food industry sources. The dietary data entry was completed by CSIRO in 1999.

The CSIRO seafood and fish database had been compiled (18) and included the fatty acid content of most Australian fish types. Therefore from the database it was possible to determine the fatty acid content of specific fish types to determine intake.

For those who ate fish infrequently, and did not mention type, ‘flake’ (shark) was assigned, as the default fish from fish and chips shops.

Serum phospholipid fatty acid analysis

Serum samples analysed for phospholipid fatty acids composition were selected if dietary intake data from questionnaires were available. The omega-6:omega-3 ratio was determined from the questionnaire and divided into quintiles. From each quintile an equal number of samples were selected. Of the 335 children for whom complete dietary questionnaires were completed, only 60 fasting venous samples were available for subsequent phospholipid fatty acid composition analyses. These samples were stored at -80°C for up to 12 months.

Phospholipid fatty acid composition analyses were conducted according to an established method (22). Serum (0.5 mL) was extracted with (CHCl3/CH3OH) (2:1, 1.5 mL). The phospholipid fraction was obtained from the total lipid extracts by thin-layer chromatography using a solvent system of hexane/diethyl ether/acetic acid/methanol at 90°C for 20 minutes. Samples were analysed by gas liquid chromatography using a Hewlett-Packard model 5980A gas chromatograph equipped with an 3393A computing integrator (Hewlett-Packard, Rockville, MD). The column was a BPX70 (25 m x 0.32 mm, 0.25 μm film thickness (SGE, Ringwood, Victoria, Australia) with a temperature range programmed from 150 to 210°C at 4°C/min and using N2 as the carrier gas at a split ratio of 30:1. Peaks were identified by comparison with a known standard mixture. Individual fatty acids were calculated as μg/mL serum.

Statistical analysis and power

Analysis of variance to compare means between groups and a Spearman’s correlation strategy were applied in the analysis to determine associations between frequency of fish intake and serum VLC omega-3 fatty acids. Frequency tables were used to investigate proportions for both the nested case control study and the subset for which serum phospholipid fatty acid analysis was completed. The levels of EPA and DHA were analysed independently and combined to form a single measure of EPA + DHA. Analysis of variance tests were conducted to compare EPA + DHA means between fish consumption categories and generate linearity F-tests. This enabled a test for differences in mean levels of serum EPA, DHA, and EPA + DHA combined, by frequency of fish consumption and fish category. Spearman’s correlation coefficient, a non-parametric test, was more appropriate than Pearson’s correlation coefficients because nutrient intakes were not normally distributed (23). Spearman’s coefficient (rho = ρ) was generated to determine associations between total omega-3 as measured from diet and total omega-3 as measured from serum phospholipids. Statistical significance as defined at the two-sided alpha level of 0.05, is reported.

Ethical approval for the study was given by the Princess Margaret and King Edward Hospital Ethics Committee.

Results

Subjects

Responses to the dietary questionnaire were received for 335 children with respiratory data (response rate of 83%). As each mother was required to visit a laboratory with the study child for blood to be drawn, the response rate in the subset was low (18%). The number of subjects by gender and asthma status for both the dietary study and the subset are given in Table 2.

Patterns of fish consumption

Very similar patterns of fish consumption were apparent in the dietary study sample (n = 335) and the subset (n = 60) (Table 3). In the dietary study sample 9% ate fish never or rarely, compared with 12% in the subset. The majority of children (30% in diet study and 33% in subset) ate fish at least once per week with 29% and 32% children, respectively, consuming fish at least twice per week. Less than half (44%, 38%) never or rarely ate canned fish and approximately 60% did not consume fish fingers. Seafood other than fish was eaten never or rarely by the majority (78%, 80%).

Table 2. Proportion of survey sample in dietary study and in phospholipid analysis

<table>
<thead>
<tr>
<th></th>
<th>Number of children from dietary study</th>
<th>Number of children with serum phospholipid fatty acid analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 335 percent</td>
<td>n = 60 percent</td>
</tr>
<tr>
<td>Children with asthma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>93</td>
<td>48</td>
</tr>
<tr>
<td>Females</td>
<td>64</td>
<td>45</td>
</tr>
<tr>
<td>Children with no asthma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>100</td>
<td>52</td>
</tr>
<tr>
<td>Females</td>
<td>78</td>
<td>55</td>
</tr>
</tbody>
</table>
There were no differences in frequency and category of fish consumption between the asthma and non-asthma groups for either the dietary study sample or the subset, other than for children with asthma whose parents reported they ate more fish fingers than children with no asthma (0.43 serves/month more; *P* = 0.01). Although parents reported that girls ate more canned fish than boys (0.59 serves/month more; *P* = 0.05) there was no difference in frequency and category of any other fish over the entire cohort.

### Types of fish (not canned or fish fingers) consumed in the subset of children

When asked to state the type of fish eaten, the answers given on behalf of the subset were: shark, snapper, dory and/or snapper, snapper and/or whiting, dory, hoki (hake/blue grenadier), snapper and/or shark, mullet and/or snapper, whiting, hake and/or snapper, herring and/or tailor, dory and/or shark, ling, perch and/or snapper, cobbler and/or dory, herring and/or mullet, hake, bream and/or dhufish and cobbler. We assumed these fish types were given on behalf of the subset were: shark, snapper, dory and/or mullet, hake, bream and/or dhufish.

### Serum phospholipid fatty acids

The mean (± SD) EPA + DHA level in serum phospholipids was 17.70 (5.55) µg/mL (range 5.78–32.90). As expected, children whose parents reported they never or rarely ate fish had lower EPA + DHA levels in serum phospholipids than those who ate fish more frequently. The EPA + DHA level in those who never or rarely ate fish was 12.93 µg/mL as compared to 19.96 µg/mL in those who ate fish twice a week or more (Table 4). There was a significant relationship, as assessed by ANOVA, between frequency of consumption of any fish and mean EPA (*P* = 0.043) and DHA (*P* = 0.001) level and mean EPA + DHA (*P* = 0.001) levels in serum phospholipids.

When broken down into fish categories there were significant relationships between mean EPA + DHA levels and frequency of fish (fried, steamed, boiled or grilled) consumption (*P* = 0.014) but not canned fish, seafood or fish fingers (Table 5).

### Estimated intake of EPA and DHA from FFQ

The mean (SD) intakes of EPA and DHA were estimated in the dietary sample by questionnaire (n = 335) (data not shown). There were significant trends for the mean totals of EPA + DHA intakes to increase with increasing frequency of fish consumption (*P* = 0.001). Spearman’s correlation coefficient tests for association were significant for frequency of fish consumption and estimated EPA (*ρ* = 0.188 *P* < 0.0005), DHA (*ρ* = 0.131 *P* = 0.015) and EPA + DHA combined (*ρ* = 0.131 *P* = 0.015). The mean total amount of EPA + DHA measured as g/day for each category of frequency of consumption by the subset (n = 60) were as follows: never or rarely (0.30), less than once a week (0.32), once to twice a week (0.34) and more than twice a week (0.46). The mean total EPA + DHA as measured by questionnaire did not correlate with the mean total EPA + DHA as measured from serum phospholipids (*ρ* = 0.125 *P* = 0.340) although both questionnaire and phospholipid data correlated with any fish consumption (*P* = 0.001). Further, total omega-3 fatty acids as measured by questionnaire correlated with total omega-3 as measured from serum phospholipid (*ρ* = 0.264 *P* = 0.044).

### Discussion

Little information exists on the fish intake of Australian children. The availability of FFQ intake data of eight-year-old asthma cases and controls from Perth, Western Australia, provided the opportunity to investigate their fish consumption patterns. No differences in frequency or

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### Table 3. The frequency of consumption of fish or seafood by children living in Perth, Western Australia

<table>
<thead>
<tr>
<th>Frequency of consumption</th>
<th>Number reporting any fish&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>Number reporting canned fish (tuna, salmon etc and includes mornay dishes)</th>
<th>Number reporting fish (fried, steamed, boiled or grilled)</th>
<th>Number reporting seafood (prawns, crab, lobster etc)</th>
<th>Number reporting fish fingers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet study</td>
<td>n = 335</td>
<td>percent</td>
<td>n = 335</td>
<td>percent</td>
<td>n = 335</td>
</tr>
<tr>
<td>Never or rarely</td>
<td>29</td>
<td>8.7</td>
<td>148</td>
<td>44.2</td>
<td>80</td>
</tr>
<tr>
<td>&lt; once a week</td>
<td>11</td>
<td>32.8</td>
<td>113</td>
<td>33.7</td>
<td>145</td>
</tr>
<tr>
<td>1– &lt; 2 a week</td>
<td>99</td>
<td>29.6</td>
<td>50</td>
<td>14.9</td>
<td>83</td>
</tr>
<tr>
<td>≥ 2 a week</td>
<td>97</td>
<td>29.0</td>
<td>24</td>
<td>7.2</td>
<td>27</td>
</tr>
<tr>
<td>Subset with serum sample</td>
<td>n = 60</td>
<td>percent</td>
<td>n = 60</td>
<td>percent</td>
<td>n = 60</td>
</tr>
<tr>
<td>Never or rarely</td>
<td>7</td>
<td>11.7</td>
<td>23</td>
<td>38.3</td>
<td>18</td>
</tr>
<tr>
<td>&lt; once a week</td>
<td>14</td>
<td>23.3</td>
<td>20</td>
<td>33.3</td>
<td>18</td>
</tr>
<tr>
<td>1– &lt; 2 a week</td>
<td>20</td>
<td>33.3</td>
<td>14</td>
<td>23.4</td>
<td>19</td>
</tr>
<tr>
<td>≥ 2 a week</td>
<td>19</td>
<td>31.7</td>
<td>3</td>
<td>5.0</td>
<td>5</td>
</tr>
</tbody>
</table>

<sup>(a)</sup>Any fish is a combination of all other fish categories including canned fish, fish (fried, steamed, boiled or grilled), seafood and fish fingers.

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category of fish consumed were detected between asthma cases and controls (except for more frequent fish fingers consumption by cases), or girls and boys (except for more frequent canned fish consumption by girls). Although there is some evidence for a role of VLC omega-3 fatty acids in the management of bronchial hyper-responsiveness (24), a feature of asthma, our data do not indicate that eight year olds with asthma in Perth are consuming fish more frequently than their counterparts without asthma.

The majority of the children were reported by their parents to be consuming fish at least once per week (59%) with 29% eating fish at least twice per week. Fish (other than canned, seafood or fish fingers) was reported to be more widely consumed than any of these specific categories. It is not known to which extent this finding can be generalised to other Western Australian or Australian children. The children were drawn from a population study and thus would be expected to be representative of Perth schoolchildren at eight years of age. The study began while the subjects were in utero, and while it might be argued that those subjects whose parents have maintained a commitment to the study are more likely to be those who place a high priority on health and thus a healthy lifestyle, the WAPCS is characterised by a remarkably high retention rate.

This is the first time that the serum phospholipid EPA and DHA levels of Australian school-aged children have been reported. The relationships between frequency of any fish consumption and serum phospholipid levels of EPA, DHA and EPA + DHA combined were significant. The FFQ asked respondents to specify the type of fish typically consumed by the children. The named fish were all lean and contained < 0.2 g EPA + DHA /100 g (18). DHA is the predominant VLC omega-3 fatty acid in these fish, which probably accounts for the stronger relationship between DHA in serum phospholipids and frequency of any fish consumed compared with EPA (Table 4) (18). Canned salmon and tuna are more concentrated sources of EPA and DHA than the fish reported to be eaten by the children in this study (14). However, analysis of variance for canned fish did not reach significance (Table 5). There are likely to be two components to the explanation for this. Firstly, the high number (38%) of children who never or rarely consumed canned fish left small numbers in the other frequency categories. Secondly, it is likely that there was more variation in the serve size of canned fish than in the general fish (fried, steamed, boiled or grilled) category, and greater difficulty for the respondent to express a child’s frequency of consumption in terms of the serve size given (1/3 cup).

A strong relationship between the frequency of any fish consumption, determined by FFQ, and phospholipid levels of EPA and DHA has been reported by another group (25), for a population mainly consuming lean fish. Others using a FFQ, have reported a significant relationship between the dietary intake of fish (26) (frequency / serve size) and serum phospholipid levels of the EPA and of DHA in adults. Because in the present study, frequency of mainly lean fish consumption significantly relates to serum phospholipid levels of EPA, DHA and EPA + DHA combined, this suggests a relatively consistent serve size of ‘any fish’ for our population of children.

The subset of children who provided a serum sample was self-selected (in that providing a fasting blood sample involved an additional visit to the study laboratory). However, given that there was no difference in frequency and category of fish consumed between the nested case control study and the subset, it can be assumed that the subset was representative of the 335 subjects for whom dietary information was obtained.

The mean total EPA+DHA as measured by questionnaire and the mean total EPA+DHA as measured from serum phospholipids both correlated with the frequency of any fish consumption. However, these two measures of EPA+DHA did not correlate with each other and confirms our reluctance to translate our frequency of fish consumption data into actual VLC omega-3 intakes. As indicated there were many limitations associated with the use of this FFQ for children; our primary concern was that the serve sizes used in the questionnaire were those used with adults (although parents were requested to report actual serve sizes used in the questionnaire were those used with adults).
size). In addition, the dietary analysis was completed before the availability of the improved database for fatty acids composition of Australian foods (27). Indeed our values differ from the estimates of adult intake derived by Meyer et al. (5) using data from the National Nutrition Survey conducted in 1995. While intake increased with increasing frequency of fish consumption, the mean EPA + DHA intake of all categories of fish consumption, including never or rarely, are at least 0.3 g/day, compared to a mean adult estimate by Meyer et al. of 0.162 g/day (5) obtained from 24-hour recalls of 10 851 adults. Therefore use of the FFQ appears to have resulted in overestimates of the combined intake of EPA + DHA in comparison with the 24-hour recall method. It should be noted that information was collected in the case control study on the use of supplements and thus it is known if fish oil capsules were consumed. Regardless of these issues it is useful to know that in a sample of children eating mainly lean fish, the patterns of fish consumption are sufficient to predict serum phospholipid levels of EPA and DHA.

Evidence for a role for fish/fish oil consumption in asthma is inconsistent. Epidemiological studies provide evidence that regular fish consumption is protective of asthma (1,28). A current Australian study supplemented high-risk infants from weaning to 18 months with fish oil (29). Data at 18 months suggest that wheeze is less prevalent in the supplemented group, however the impact on the prevention of asthma is not yet known. In relation to control of asthma, the authors of a recent Cochrane review concluded that there is little evidence to recommend that people with asthma use marine omega-3 fatty acids (fish oils) to improve their asthma control (28).

Despite the lack of agreement on the value of fish/fish oils in the prevention or management of asthma, it is important to investigate VLC omega-3 fatty acids status in Australian children as it is not known whether serum phospholipid levels of EPA and DHA differ between children with and without asthma. Our dietary study of 335 eight-year-old children showed no evidence of differing fish consumption patterns between children with asthma and those without asthma, a finding, which concurs with the lack of differences in the serum phospholipid EPA, and DHA levels between these two groups in our subset (n = 60) of Perth children.

Although food frequency questionnaires, both qualitative and quantitative, have been used to estimate various nutrient intakes in adults and children, we recommend that standard serve sizes for Australian children be developed and validated. It is also important that the questions in the questionnaires target the current food supply in order to capture as much information as possible to support coding decisions. An example of this is the recent proliferation of crumbed fish meal products; the amount of fish in a standard serve of these products may not necessarily be the same as that in home-prepared crumbed fish.

**Conclusion**

Our study reveals that the majority of children in the nested case control study were reported to consume fish at least once per week (59%) with at least 29% eating fish at least twice per week. A substantial proportion of children (44%) never or rarely consumed canned fish. Frequency of ‘any fish’ intake was reflected in the EPA and DHA intakes as measured by questionnaires, supporting the finding for Australian adults that fish is the main source of these VLC omega-3 fatty acids (5). Serum phospholipid levels of EPA, DHA and the combined variable, EPA + DHA, in a subset of children reflected the frequency of fish consumption (any fish and general fish categories). This supports the finding in adults that frequency of fish consumption is related to serum phospholipid levels of EPA and DHA (7). It is likely that this relationship holds in Australia because of the similarity of VLC omega-3 fatty acid levels in the fish predominantly consumed, and the use of a relatively constant serve size. While canned fish are richer sources of the VLC omega-3 fatty acids, less than half the children in our study consumed these products in 1999.

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