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Are we consuming enough long chain omega-3 polyunsaturated fatty acids for optimal health?

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Abstract

The health benefits attributed to the consumption of long chain omega-3 polyunsaturated fatty acids (LC n-3PUFA) are enormous but are we consuming enough for optimal health? Cardiovascular disease rates are much lower in countries like Japan compared with the Western world. Western countries' LC n-3 PUFA intakes are up to 5 fold lower than Japanese intakes. Various professional bodies and government organisations recommend 500mg LCn-3PUFA per day. The actual reported intake of LC n-3 PUFA from Australia and various other countries are compared to these recommended intakes. Not surprisingly, the actual intakes of LCn-3PUFA in Western countries fall short of the recommended intakes. Consumption of fish and seafood is the easiest way to achieve the recommended intakes but increased consumption of foods enriched with LCn-3PUFA will also contribute to achieving the recommended intakes. Most people are not consuming enough LCn-3PUFA for optimal health.

Keywords

health, long, optimal, enough, consuming, we, acids, fatty, polyunsaturated, 3, omega, chain

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Summary

The health benefits attributed to the consumption of long chain omega-3 polyunsaturated fatty acids (LC n-3 PUFA) are enormous but are we consuming enough for optimal health? Cardiovascular disease rates are much lower in countries like Japan compared with the Western world. Western countries' LC n-3 PUFA intakes are up to 5 fold lower than Japanese intakes. Various professional bodies and government organisations recommend 500 mg LC n-3 PUFA per day. The actual reported intake of LC n-3 PUFA from Australia and various other countries are compared to these recommended intakes. Not surprisingly, the actual intakes of LC n-3 PUFA in Western countries fall short of the recommended intakes. Consumption of fish and seafood is the easiest way to achieve the recommended intakes but increased consumption of foods enriched with LC n-3 PUFA will also contribute to achieving the recommended intakes. Most people are not consuming enough LC n-3 PUFA for optimal health.

INTRODUCTION

Long chain omega-3 polyunsaturated fatty acids (LC n-3 PUFA) have been attributed with numerous health benefits [GISSI 1999, von Schacky 1999, de Logeril 1999, Siscovik 1995, Connor 1995, Simopolous 1999]. This review will provide an overview of Australian and global intakes of LC n-3 PUFA, discuss the health benefits focussing on cardiovascular disease and compare the current intakes to the various recommendations both for fish consumption and for LC n-3 PUFA recommended intakes. How to achieve the recommended intakes will also be discussed.

AUSTRALIAN AND GLOBAL INTAKES OF LC N-3 PUFA

Australian LC n-3 PUFA intakes

The Australian 1995 National Nutrition Survey (NNS95) was conducted in 10,851 adults (aged 19 and over) and 3,007 children aged 2-18 years. Dietary data was collected from February 1995 to March 1996 and therefore covered all seasons and the selected highlights were first published in 1997 [McLennan & Podger 1997]. Total PUFA were included in this initial report, but not the LC n-3 PUFA. These were subsequently analysed by Meyer et al and the average adult LC n-3 PUFA intakes was 189mg/day with fish/seafood being the main source (71%) of LC n-3 PUFA [Meyer et al 2003]. For more information regarding LC n-3 PUFA per sex and age category please refer to Meyer et al [2003].

Even though fish/seafood was by far the major food source of LC n-3 PUFA, Australians do not consume a great deal of fish/seafood and on average consumed only 26g per day [McLennan & Podger 1997]. Australian people consume quite a lot of meat and on average consume 158g/day, which is 6 fold higher than fish/seafood [McLennan & Podger 1997]. Meat contains LC n-3 PUFA in much smaller amounts compared with fish/seafood and docosapentaenoic acid (DPA) is the main LC n-3 PUFA found in meat [Howe et al 2007]. Given the 6 fold higher consumption of meat compared with fish/seafood, meat was the second highest contributor (20%) to LC n-3 PUFA intakes [Meyer et al 2003].

Since the publication of estimated intakes of 189mg LC n-3 PUFA per day in 2003 [Meyer et al 2003], updated analytical data on meat became available [Williams 2007]. As meat contributed to LC n-3 PUFA intakes the NNS95 was re-analysed using this updated data on meat and the new LC n-3 PUFA intakes was 246mg/day [Howe et al 2006]. Fish/seafood was still the main contributor to LC n-3 PUFA intakes at 48% with meat contributing 43% to LC n-3 PUFA intakes. This is more than double the previous estimate and therefore highlights the need for analytical data on foods. Meat containing cereal based products contributed 4% and eggs (approx 5%) also contribute to LC n-3 PUFA intakes [Howe et al 2006].

The most recent dietary survey undertaken in Australia is the 2007 Australian National Children's Nutrition and Physical Activity Survey [Commonwealth of Australia 2008], commonly known as the Kids Eat Kids Play survey. This survey collected data from 4,487 children aged 2-16 years from February 2007 to August in 2007 [Commonwealth of Australia 2008]. The dietary data was collected as two separate 24 hour recalls recorded 7-21 days apart and the report contained total PUFA intake but not LC n-3 PUFA intakes [Commonwealth of Australia 2008]. The median intakes were recently analysed by Meyer & Kolanu [2010] and 2-3 year olds, 4-8 year olds, 9-13 year olds and 14-16 year olds consumed 56mg/day, 68mg/day, 88mg/day and 98mg/day, respectively [Meyer Kolanu 2010].

Children on average consumed 13g fish/seafood per day and 106g meat, poultry and game products and dishes per day, which is 8 fold higher than fish/seafood [Meyer & Kolanu 2010]. Even though fish/seafood is the greatest source of LC n-3 PUFA, approximately 80% of Australian children do not consume fish/seafood, and therefore fish/seafood only contributed 33% to LC n-3 PUFA intakes [Meyer Kolanu 2010]. Given that meat was consumed by most children, meat also contributed 33% to LC n-3 PUFA intakes [Meyer Kolanu 2010]. The other contributions to LC n-3 PUFA intakes were milk products and dishes (8%), supplements (8%), cereal-based products and dishes (7%) and eggs (4%) [Meyer Kolanu 2010].

Global LC n-3 PUFA intakes (Table 1)

Historically the Eskimos consumed approximately 13g of LC n-3 PUFA [Bang et al 1980]. More recently dietary analysis of Inuit of Nunavik, Canada estimate EPA and DHA intake at approximately 2g/day [Dewailly et al 2003].

The Japanese LC n-3 PUFA intake in 1993 was estimated at 1.6g per day [Sugano], and more recently in 1999 estimated at 0.91g per day [Hino et al]and in 2003 estimated at 0.81g per day [Nakamura et al 2003]. It appears over time that the dietary intake of LC n-3 PUFA in Japan is decreasing.

When the Japanese migrated to other countries such as Honolulu Hawaii, the estimated LC n-3 PUFA intake in 2003 was 0.31g per day which is a 75% reduction in intakes due to the adoption of local diets, rather than maintaining their traditional diets [Nakamura et al 2003].

Another point to note about the Japanese intakes of LC n-3 PUFA is that the mean intake is equal to the median intake indicating a normal distribution of intakes. Whereas in Australia and other countries the LC n-3 PUFA intakes is skewed to the right indicative of a few people consuming large amounts and the vast majority of people consuming small amounts of LC n-3 PUFA.

In France the median LC n-3 PUFA intakes (364mg/day) were 80% of the mean intakes (450mg/day) which was approximately half the Japanese intakes but approximately double the Australian intakes. The other countries median LC n-3 PUFA intakes range from 100mg/day to 239mg/day, which is much lower than the Japanese (Table 1).

Limitations of the comparisons of the global LC n-3 PUFA intakes include 1) different dietary intake methodologies, 2) specific valid tools versus generic tool to assess intakes, 3) analytical data versus calculated or derived data, and 4) utilising different databases from different countries. For example, in Australia grass fed beef contains double the amount of EPA and 1.3 fold higher amounts of DPA compared with grain fed beef [Ponnampalam et al 2006]. In the USA range fed (or grass fed) beef contains 5 times more EPA, 3 times more DPA and double the amount of DHA compared to feed lot (grain fed) beef [Rule et al 2002]. In Australia beef cattle are primarily grass fed whereas in the USA beef cattle are primarily feedlot (grain fed) and therefore Australian beef contains higher amounts of LC n-3 PUFA compared to American beef. Hence utilising different databases from different countries to assess the LC n-3 PUFA intake could result in either under- or over-estimating the true intakes.

To overcome these limitations, we have developed and validated a specific food frequency questionnaire (FFQ) that assesses LC n-3 PUFA intakes [Sullivan et al 2006, 2008]. This FFQ utilises Australian analytical data to calculate the LC n-3 PUFA intakes. This FFQ has been extended to include questions on alpha-linolenic acid and the main omega-6 PUFA (linoleic and arachidonic acids) and has also been converted into an electronic format. This new electronic PUFA FFQ has recently been validated using the method of triads which produced validity coefficients for erythrocytes of 0.9, 0.7 and 0.8 for EPA, DHA and LC n-3 PUFA respectively [Swierk et al 2010]. One limitation of this PUFA FFQ is that it is based on Australian foods, but we are currently making a New Zealand version of this PUFA FFQ. This electronic PUFA FFQ is available for research purposes - contact the corresponding author.

GLOBAL FISH AND MEAT CONSUMPTION

The Inuit people of Nunavik, Canada consume the largest amount of fish/seafood (131g/day) and the Japanese consume approximately 85g of fish/seafood per day which is greater than their meat (60g per day) consumption (Table 2). Other countries consume approximately 110-160g meat per day and only 12-45g fish/seafood per day. Therefore other countries consume 2-7 fold less fish/seafood and 2-3 fold higher amounts of meat than the Japanese. It has been reported that consumption of 85g of fish/seafood is required for cardiovascular disease risk reduction [Yamagishi et al 2008] and the Canadian Inuits and the Japanese are the only ones making this recommendation and their rates of mortality from cardiovascular disease are much lower (see below).

HEALTH BENEFITS OF LC N-3 PUFA

The need for LC n-3 PUFA during pregnancy for fetal neurological growth and development is well recognised [Makrides 2001, Al 1995, Martinez 1998] and 200mg DHA during pregnancy and lactation is recommended [Kolentzko et al 2007]. The International Society for the Study of Fatty Acids and Lipids (ISSFAL) supports this recommendation [ISSFAL website]. In Australia at least, pregnant women are not meeting the recommended intakes and they are only consuming 100mg DHA per day [Cosatto et al 2010]. In Belgium, women of child bearing age consume approximately 199mg EPA and DHA per day [Sioen et al 2010] suggesting that DHA alone is less than 200mg per day. Therefore (pregnant) women are not consuming enough DHA for optimal health and these women, especially pregnant women, need to be targeted and educated on the importance of DHA during pregnancy.

Some pregnant women think that consuming fish/seafood during pregnancy may be harmful because of the potential contaminants in fish/seafood [Sinikovic et al 2009]. However, research indicates the contrary in that women who had consumed at least 340g fish/seafood per week during pregnancy, their 8 year old offspring had higher verbal IQ than the offspring of women who did not consume fish/seafood [Hibbeln et al 2007].

There is very little known about the actual LC n-3 PUFA needs for children. It is known that babies [Demmelmair et al 1995, Szitanyi et al 1999] and children [Vlaardingerbroek et al] can synthesise arachidonic acid from linoleic acid, hence there is no great need to consume arachidonic acid directly in our diet as there is plenty of linoleic acid being supplied in our diets, which is readily converted to arachidonic acid. Children with amino acid metabolism disorders who do not consume animal protein (hence no fish/seafood, meat, eggs) and they only consume vegetable sources which supplies linoleic acid have normal arachidonic acid levels indicating that elongation and desaturation of linoleic acid to arachidonic acid is normal in these children [Vlaardingerbroek et al]. However, these same children have 30% reduced DHA levels compared to children without amino acid metabolism disorders and therefore these children are unable to elongate and desaturate alpha-linolenic acid to DHA in sufficient amounts for normal physiological health [Vlaardingerbroek et al]. This suggests that children should consume pre-formed DHA levels rather than rely on the conversion of alpha-linolenic acid to DHA.

By far the bulk of the scientific evidence regarding the health benefits of LC n-3 PUFA is cardiovascular disease. The incidence of CVD in Japan is much lower than other countries [Mozzafarian]. The rate of cardiac death per 1000 persons is 8 fold higher in the GISSI prevenzione trial (Italian population) compared to the JELIS trial (Japanese population) [Mozzafarian]. In the GISSI prevenzione trial, fish oil supplementation (approximately 290mg EPA and 590mg DHA per day) in Italian people with previous myocardial infarction resulted in a 20% reduction in total mortality, 30% reduction in cardiovascular death, 35% reduction in coronary death and a 45% reduction in sudden death [Lancet 1999]. The JELIS trial, fish oil supplementation (approximately 1.8g EPA per day) in Japanese, hypercholesterolaemic subjects already taking statin drugs resulted in a 19% reduction in major coronary events and primarily effective in the secondary prevention group [Yokoyama et al 2007].

The triglyceride lowering effect of fish oils has been well documented [Harris 1997]. One recent dose response trial suggest the lowest dose necessary for triglyceride lowering is 1.3g LC n-3 PUFA per day which resulted in 20% reduction in plasma triglyceride levels with the 2g dose showing a 25% reduction [Milte et al]. Another dose response study suggest that the lowest dose 0.35g per day had no effect whilst the 0.7g dose suggested a reduction (not significant) and the 1g dose significantly reduced plasma triglycerides by approximately 20% in pre-menopausal women [Sparkes et al 2010]. However, in people with combined hyperlipidaemia already taking statins to lower their plasma cholesterol levels, higher doses of fish oil (8g per day containing 2.16g DHA and 0.56g EPA) were required to reduce plasma triglycerides by 27% [Meyer Hammervold et al 2006].

Apart from the hypotriglyceridaemic effect of fish oil supplementation, changes in LDL and HDL have also been reported. A review by Harris showed that 4g fish oil supplementation resulted in a 5-10% increase in LDL-C and a 1-3% increase in HDL-C [Harris 1997]. A more meta-analysis on LC n-3 PUFA supplementation on plasma lipids showed that LC n-3 PUFA supplementation (ranging from 0.045-5.4g/day and approx average of 2.7g/day) resulted in 0.31mmol/L reduction in plasma triglycerides, an increases of 0.04mmol/L and 0.16mmol/L in HDL-C and LDL-C respectively [Balk et al 2006]. It has also been reported that the increase in LDL-C is related to the increase in the particle size of LDL [Contacos et al 1993; Mori et al 2000; Suzukawa et al 1995]. The increase in HDL-C is an increase in HDL_{2b} particles which are more cardioprotective than HDL_3 particles [Thomas et al 2004; Mori et al 2000].

The blood pressure lowering effect of fish oils suggests doses of 3-4g are required as reviewed by Mori [Mori 2006]. However some studies have shown lower doses of fish oil to be effective in lowering blood pressure especially those not already taking drugs for hypertension. In one study where less than 20% of participants were on medication for blood pressure, 1g dose of fish oil or seal oil was enough to see a reduction in systolic blood pressure of 5mmHg and 8mmHg, respectively [Meyer et al 2009]. In an totally untreated population, doses of 150mg DHA and 30mg EPA were effective in reducing systolic blood pressure by 14mmHg [Vericel et al 1999].

LC n-3 PUFA have the ability to reduce blood clotting by affecting anti-platelet aggregation through differing actions on thromboxane production in platelets. Both EPA and DHA can competitively displace arachidonic acid from platelet phospholipids (Kinsella et al. 1990). Eicosapentaenoic acid and DHA can competitively bind to cyclo-oxygenase, excluding arachidonic acid from the active site (Cory et al. 1983); furthermore, both EPA and DHA interfere with the binding of thromboxane to its platelet receptor involved in the aggregation step (Swann et al. 1989). All these functions result in reduced thromboxane production and/or platelet aggregation. In addition to EPA and DHA, docosapentaenoic acid (DPA) has also been shown to have anti-platelet aggregation effects. In an in vitro study using rabbit platelet rich plasma incubated with EPA, DHA or DPA and subsequently stimulated with collagen, arachidonic acid or prostaglandin F2α, DPA was found to be the most potent platelet aggregation inhibitor (Akiba et al. 2000). More recently, supplementation with 1g/day of seal oil (rich in DPA) has been shown to markedly reduce p-selectin expression, a marker of platelet aggregation [Mann et al 2010] providing further support that DPA may be more important than EPA and DHA in terms of inhibiting platelet aggregation, although studies with purified DPA are warranted.

LC n-3 PUFA RECOMMENDATIONS AND COMPARISON TO ACTUAL INTAKES

There are various recommendations for either fish consumption and/or LC n-3 PUFA (primarily EPA and DHA) intakes. The majority of organisations recommend 2 serves of fish per week with at least one of them being an oily fish. This recommendation would provide on average approximately 500mg EPA and DHA per day, which is what most countries recommend for optimal health and reducing the risk of chronic disease such as cardiovascular disease (Table 3).

There are other recommendations of 1000mg EPA and DHA per day for secondary prevention [AHA 2002; European Society of Cardiology 2003; NHFA 2008]. This recommendation is primarily based on the GISSI prevenzione trial [GISSI-Prevenzione Investigators 1999].

Apart from the Inuit of Nunavik, James Bay Cree Canada and the Japanese living in Japan, the rest of the world's population are not meeting the recommended intakes for optimal health. Some countries need to increase their LC n-3 intakes by at least 5 fold.

ACHIEVING THE RECOMMENDATIONS

Fish (preferably oily fish) and seafood is the richest source of LC n-3 PUFA and hence its consumption is the easiest way to increase the LC n-3 PUFA intakes. However, increasing fish/seafood consumption is easier said than done because apart from the Inuit of Nunavik and the traditional Japanese, most countries consume approximately 5 fold more meat, poultry and game than fish/seafood. In Australia at least, 80% of children do not consume fish/seafood [Meyer Kolanu 2010]. However, the 20% of children that do consume fish/seafood, their LC n-3 PUFA intakes meet the recommended intakes, whereas the children that do not consume fish/seafood they generally do not meet the recommended LC n-3 PUFA intakes [Meyer Kolanu 2010]. In a Belgian study, it has been reported that fish consumption was highest in women, over 40 years of age who were living on the coast of Belgium and if children were present in the household, fish consumption decreased [Verbeke Vackier 2005]. The reasons for not consuming fish/seafood included the unpleasant smell, fish is expensive, bones are unpleasant, difficult to prepare and difficult to judge the quality of fish and make a bad choice at point of purchase [Verbeke Vackier 2005]. The food industry has partially overcome these barriers by supplying quality canned fish, some without bones. In Australia at least canned fish including flavoured ones (e.g. mango and chilli) in convenient lunch size cans are widely available and it will be interesting to see in the new Australian National Survey if this has an impact on total fish/seafood consumption and LC n-3 PUFA intakes.

An alternative to increasing fish/seafood consumption is to consume fish oil supplements. In the recent nutrition survey in Australia 4% of Australian children take such supplements. This is similar to other countries like Belgium where 5% of Belgian women take fish oil supplements [Sioen et al 2010] but much lower than other countries like Quebec (21%) [Lucas et al PHN 2010]. Encouraging increased consumption of fish oil capsules would easily translate in increased omega-3 status.

Another option is consumption of foods that have been enriched with LC n-3 PUFA. We have shown that consumption of these enriched foods (breads, cereal, milk, dry soup, eggs, margarine, biscuits, dips, cheese spread, salad dressing, pancake and chocolate) collectively providing 700mg EPA and DHA per day increased the omega-3 index [Harris & von Schacky 2004] from 4% to 7% after 6 months [Murphy et al 2007]. However, enriched foods only contribute a small proportion of the LC n-3 PUFA intakes with approximately 1% in the KEKP survey [Meyer Kolanu 2010] and 3% in Belgian women [Sioen et al 2010].

Recently we have conducted dietary modelling to determine various ways of achieving the recommended intakes of LC n-3 PUFA [Fayet et al 2010]. As can be seen from table 4, consuming 2 fish meals per week will provide enough LC n-3 PUFA. For the non-fish consumer, meat and 3-8 serves of enriched foods including enriched eggs will meet the recommended intakes [Fayet et al 2010]. The lacto-ovo-vegetarians are harder to achieve the recommended intakes, as 5-10 serves per day of enriched foods are needed [Fayet et al 2010]. This group could also consider consuming micro-algal DHA capsules to meet the recommendations.

In summary, there is generally a global consensus on the recommendation of consuming 2 fish meals per week and preferably oily fish. There is also a consensus of a recommendation of 500mg LC n-3 PUFA per day and a separate recommendation of 200mg DHA per day for pregnant and lactating women. Apart from Inuit of Nunavik and the Japanese, people are not meeting these recommended intakes of fish and LC n-3 PUFA for optimal health. Fish/seafood consumption is the easiest way to meet the recommended intakes, but these can also be achieved by consumption of enriched foods with LC n-3 PUFA.

In conclusion, most people are not consuming enough LC n-3 PUFA for optimal health.

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Table 1 Median LC n-3 PUFA intakes (mg/day)

Country	Population	Year of data collection	Median intakes (mg/day)	Reference
Greenland	Eskimos	1976	13000	[14]
Canada	Inuit of Nunavik	1992	2115	[15]
	James Bay Cree	1992	800	[15]
	Quebec	1992	170	[15]
	Quebec	~2008	207*	[20]
Japan	Kyushu, SW island of Japan	1999	905	[17]
	INTERLIPID Study Aito Town	2003	810	[18]
	INTERLIPID study Japanese living in Hawaii	2003	310	[18]
France	All regions of France	1995	364	[19]
Nth Sth Europe	7 centres in Europe	2003	239	[21]
Belgium women	Women living in Flanders	2009	199	[22]
Australia	1995 National Nutrition Survey	1995	170	[11]
Germany	German Nutrition Survey	1998	160	[23]
USA	USDA	1994-1996	~115	[24]
	6 multi-ethnic communities	2002	100	[25]
The Netherlands	Rotterdam coronary calcification study	1993	97*	[26]

* EPA and DHA

Table 2 Fish, meat and eggs consumption (mean g/day)

Country	Population	Year of data collection	Fish consumption (g/day)	Meat consumption (g/day)	Egg consumption (g/day)	Reference
Canada	Inuit of Nunavik	1990-1992	131	nr	nr	[15]
	James Bay Cree	1990-1992	60	nr	nr	[15]
	Quebec	1990-1992	13	nr	nr	[15]
	Quebec	~2008	37	nr	nr	[20]
Japan	Aito, Shiga, Japan	1997-1998	84	53	30	[32]
Italy	Italian National Food consumption Survey	2005-2006	45	110	21	[33]
France	All regions of France	1995	44	159*	#	[19]
Belgium women	Women living in Flanders	2009	32	nr	nr	[22]
Australia	1995 National Nutrition Survey	1995	26	158	14	[7]
USA	Male health physician study	1986	30	160	nr	[34]
	USDA survey	1994-1996	~23g	~166g	18	[24]
The Netherlands	Rotterdam coronary calcification study	1993	12^	113	nr	[26]

* contains eggs; # reported together with meat; ^ median consumption; nr not reported

Table 3 Global recommendations for fish and LC n-3 PUFA intakes (mg/day)

Recommendations	Country or Organisation	References
Fish recommendations		
1-2 fish meals per week	FAO/WHO	[66]
2 fish meals per week preferably oily or at least one oily	The Netherlands	[67]
	Australia	[68]
	America	[69,70]
	Europe	[71]
2 fish meals per week preferably fatty fish	Belgium	[72]
LC n-3 PUFA recommendations		
200-500mg EPA and DHA per day	FAO/WHO	[66]
450mg EPA and DHA per day	The Netherlands	[67]
430-570mg EPA and DHA per day	America	[69]
500mg EPA and DHA per day	America	[70]
	Australia	[68]
	ISSFAL	[40]
500mg EPA and DHA per day plus 120mg DHA minimum	France	[73]
430mg EPA, DPA and DHA per day for women	Australia	[74]
610mg EPA, DPA and DHA per day for men	Australia	[74]

Table 4 How to achieve the recommended LC n-3 PUFA intakes from natural and omega-3 enriched foods

Food	Amount	LC n-3 PUFA (mg)
Oily Fish		
Pink Salmon canned in water	100g	1665
New Zealand King Salmon	100g	1335
Lean Fish		
Bird's Eye Fish Fillet, frozen (1 fillet)	100g	206
Bird's Eye Smart Choice crumbed fish fillet (1 fillet)	100g	156
Tuna in springwater	75g	172
John West kids tuna	75g	80
Eggs		
Normal eggs	2 eggs	50
Omega-3 enriched eggs	2 eggs	280
Omega-3 enriched dairy foods		
Pura milk (1 cup)	250ml	53
Vaalia toddlers yoghurt	1 tub	53
Lean red meat	100g	36
Omega-3 enriched bread	2 slices	34

Table 5 Weekly food intake to meet LC n-3 PUFA recommendations for all life-stages [79].

Food	High fish consumers	Low/medium fish consumers	No fish consumers	Lacto-ovo-vegetarians
Fish	2 serves of high	2 serves (1 high; 1 med or low)	nil	nil
Meat	nil	3-4 serves	4 serves	nil
Eggs[+]	nil	0-2 eggs	nil	nil
Enriched foods[++]	Nil	3-26 serves	20-59 serves	37-66 serves

+ Whole, non-enriched eggs.

++ Includes enriched eggs.