Dietary Intakes and Food Sources of Omega-6 and Omega-3 Polyunsaturated Fatty Acids

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ABSTRACT: Both n-6 and n-3 polyunsaturated fatty acids (PUFA) are recognized as essential nutrients in the human diet, yet reliable data on population intakes are limited. The aim of the present study was to ascertain the dietary intakes and food sources of individual n-6 and n-3 PUFA in the Australian population. An existing database with fatty acid composition data on 1690 foods was updated with newly validated data on 150 foods to estimate the fatty acid content of foods recorded as eaten by 10,851 adults in the 1995 Australian National Nutrition Survey. Average daily intakes of linoleic (LA), arachidonic (AA), α-linolenic (LNA), eicosapentaenoic (EPA), docosapentaenoic (DPA), and docosahexaenoic (DHA) acids were 10.8, 0.052, 1.17, 0.056, 0.026, and 0.106 g, respectively, with long-chain (LC) n-3 PUFA (addition of EPA, DPA, and DHA) totaling 0.189 g; median intakes were considerably lower (9.0 g LA, 0.024 g AA, 0.95 g LNA, 0.008 g EPA, 0.006 g DPA, 0.015 g DHA, and 0.029 g LC n-3 PUFA). Fats and oils, meat and poultry, cereal-based products and cereals, vegetables, and nuts and seeds were important sources of n-6 PUFA, while cereal-based products, fats and oils, meat and poultry, cereals, milk products, and vegetable products were sources of LNA. As expected, seafood was the main source of LC n-3 PUFA, contributing 71%, while meat and eggs contributed 20 and 6%, respectively. The results indicate that the majority of Australians are failing to meet intake recommendations for LC n-3 PUFA (>0.2 g per day) and emphasize the need for strategies to increase the availability and consumption of n-3-containing foods.

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Considering the importance of different fatty acids in relation to health, especially the n-3 polyunsaturated fatty acids (n-3 PUFA), there is a paucity of information on current intakes and the contribution of different food groups to their intakes. Moreover, there is considerable variation in recommended intakes for PUFA in adults (Table 1). Recommended intakes for LA range from 4.4–20 g/d; LNA ranges from 1.35–2.2 g/d, and LC n-3 PUFA range from 0.16–1.6 g/d (Table 1; 1–8). Hence, there are large differences in existing recommendations, and the feasibility of their adoption depends on current intakes, for which reliable information is lacking.

Sinclair *et al.* (9) estimated the intake of LC n-3 PUFA by analying the plasma phospholipid fatty acids in 108 healthy adult male and female Australians and calculated this to be about 0.1 g/d. In a study by Mann *et al.* (10) based on Australian dietary intake data from 1983, adults were consuming approximately 100 mg/d of arachidonic acid (AA, 20:4n-6) and a similar amount of EPA and DHA combined (10). Ollis *et al.* analyzed weighed food records from 83 men and women residing in the Illawarra region of New South Wales in Australia and estimated the intake of LC n-3 PUFA to be 0.18 g/d (11). However, this study was only a small-scale study using limited food composition fatty acid data. This raises the question of validity of the results being representative of the Australian adult population. Since then we have established an updated fatty acid database (12) and used it to extend the 1995 National Nutrition Survey nutrient database (AUSNUT) (13) to contain a total of 32 individual and subtotals of fatty acids (14).

The aim of this study was to apply this extended AUSNUT database (14) to food consumption data measured in the 1995 National Nutrition Survey (NNS) to determine more reliably the total intakes and food sources of fatty acids in the Australian diet.

METHODS

The fatty acid database was developed using the existing Nutrient Table (NUTTAB) released in 1995 (NUTTAB95) fatty acid supplement database supplied by Food Standards Australia and New Zealand (FSANZ), as g fatty acid/100 g edible portion (two decimal places). A total of 449 foods from a total of 1116 foods in the existing database were eliminated. This number included many meat and egg entries that failed to report the presence of LC PUFA and other food items where fatty acids had been misidentified. In most cases, this

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Abbreviations: α-linolenic acid (α-LNA, 18:3n-3); arachidonic acid (AA, 20:4n-6); docosahexaenoic acid (DHA, 22:6n-3); docosapentaenoic acid (DPA, 22:5n-3); eicosapentaenoic acid (EPA, 20:5n-3); European Academy of Nutritional Sciences (EANS); Food Standards Australia New Zealand (FSANZ); International Society for the Study of Fatty Acids and Lipids (ISSFAL); linoleic acid (LA, 18:2n-6); long-chain n-3 polyunsaturated fatty acids (LC n-3 PUFA, 20:5n-3, 22:5n-3, and 22:6n-3); National Health and Medical Research Council (NHMRC); National Heart Foundation (NHF); National Nutrition Survey (NNS); megajoules (MJ); monounsaturated fatty acids (MUFA); n-3 polyunsaturated fatty acids (n-3 PUFA); n-6 polyunsaturated fatty acids (n-6 PUFA); saturated fatty acids (SFA).

TABLE 1
Various International Recommendations for Entire Populations for Polyunsaturated Fatty Acid (PUFA) Intakes (g/d and % energy)

	Ref.	LA	Total n-6 g/d (% energy)	LNA n-3	LC n-3
NHMRC Australia, 1992[b]	1	—	12 (6)	2.0 (1)	—
BNF, 1992[c]	2	12 (6)	—	2.0 (1)	1.0 (0.5)
Japanese, 1996[b,c]	3	10–12 (5–6)	—	2.0 (1)	1.6 (0.8)
EANS, 1998	4	—	—	2.0 (1)	0.21 (0.11)
Simopolous *et al.*, 1999	5	4.4–6.7 (2.2–3.4)	—	2.2 (1.1)	0.65 (0.33)
NHF of Australia, 1999	6	—	16–20 (8–10)	≥2.0 (1)	0.16–0.43[d] (0.08–0.22)
Omega-3 working group Germany, 2002	7	—	—	—	≥0.3 (0.15)
United States/Canada, 2002[b]	8	14–15[e] (7)	—	1.35 (0.68)	<0.135[f] (0.07)

[a]Abbreviations: LA, linoleic acid; LNA, linolenic acid; LC, long-chain; NHMRC, National Health and Medical Research Council; BNF, British Nutrition Foundation; EANS, European Academy of Nutritional Sciences; NHF, National Heart Foundation; —, not reported.
[b]Government agencies.
[c]Based on average intakes.
[d]Estimated from two fish meals per week (lean – fatty fish).
[e]Average estimate of male and female intakes.
[f]10% of LNA intake.

was due to the low sensitivity and poor resolving power of packed column gas chromatography analyses that were in use at the time of measurement. More recent fatty acid composition data on approximately 400 other foods from 27 reputable Australian research studies or industry projects were added to the database. The details of the database and contributors have been published elsewhere (12). The database has been incorporated into dietary analysis software in Australia and can be viewed at http://www.xyris.com.au.

Australians' fatty acid intakes, and the food sources of these fatty acids, were estimated using FSANZ's DIAMOND dietary exposure program by applying the fatty acid extension of the Australia Nutrient (AUSNUT) database (containing nutrient data for 4,554 foods) to the individual 24-h dietary intakes of 13,858 respondents in the 1995 National Nutrition Survey (NNS) (15). Dietary data were collected from February 1995 until March 1996 and thus cover all seasons (15).

The DIAMOND program is a custom application developed and used by FSANZ (FSANZ, Canberra, ACT, Australia) to estimate actual or theoretical dietary exposures to chemicals in food. In this study, the DIAMOND computation procedure first calculated the intakes of individual and subtotal fatty acids corresponding to the single 24-h food consumption record of each Survey respondent in the population group of interest. Summary statistics for each fatty acid such as mean (mg/d) and median intakes (mg/) were then generated for each Survey population group. To account for total energy intake, the estimated means were divided by the reported total energy intake for that age and sex category and expressed as mg/d/MJ. Food sources of individual fatty acids were calculated on the basis of the contribution of each major food group to the total of each fatty acid intake for adults aged over 19 yr.

It should be noted, however, that the results were not adjusted for intra-individual variation over time, nor were population weights applied. This means that there are likely to be small differences between our results for fatty acid subtotals such as total PUFA and the official published NNS data. First, extremes of intake are likely to be exaggerated when derived from a single 24-h period, rather than being averaged over a longer period of time. Second, the distribution of age/sex categories in the Survey sample was not adjusted to represent the whole Australian population. However, this is unlikely to make a significant difference to the mean and median results. More information on the NNS data and adjustments of the data can be found in the Technical Paper, NNS, Confidential Unit Record File 1995, Australian Bureau of Statistics, Canberra.

RESULTS

Table 2 shows the estimated mean intakes (in mg/d and mg/d/MJ) of the individual and total n-6 PUFA, the individual and total n-3 PUFA, and the total LC n-3 PUFA for all age groups (males and females combined). Adults consume more LC n-3 PUFA than children 18 yr and younger, whether expressed as mg/d or mg/d/energy (Table 2).

Table 3 shows the estimated mean fatty acid intakes [in mg/d and mg/d/energy (MJ)] for adult females and males. Adult males consume more fatty acids (mg/d) compared with females in the same age category. When total energy intake is taken into account, these differences disappear. It is not possible to determine the fatty acid intake as mg/d/energy (MJ) for the 19–64-yr-old category, as the energy intake for the 19–64 yr age category is not available. However, it is interesting to note that adults aged 65 and over have higher total intakes of EPA (33%) and DHA (26%) and hence total LC n-3 PUFA (27%) compared with the adults (19 yr and over). This would suggest that adults aged 65 and over also have higher intakes per MJ energy than the 19–64 yr as the 65 yr and over age category is a subset of the 19 yr and over age category. In essence, the older adults (65 yr and over) consume more LC n-3 PUFA than younger adults. It is also interesting to note

TABLE 2
PUFA Intakes for All Ages[a,b]

	All persons Age (yr)														
	Fatty acid intake (mg/d)								Fatty acid intake [mg/d/energy (MJ)]						
	2–3	4–7	8–11	12–15	16–18	19+	19–64	65+	2–3	4–7	8–11	12–15	16–18	19+	65+
n	383	799	739	653	433	10851	8891	1960	383	799	739	653	433	10851	1960
Energy intake (MJ)	6.3	7.4	9.0	10.1	11.2	9.2	ND	7.3	6.3	7.4	9.0	10.1	11.2	9.2	7.3
n-6 PUFA															
18:2	6100	7500	9900	10700	11700	10800	11200	9100	960	1008	1100	1059	1047	1169	1247
20:2	2	3	5	6	5	6	6	5	0.3	0.4	0.6	0.6	0.4	0.6	0.7
20:3	16	23	27	31	35	38	39	32	2.5	3.1	3.0	3.1	3.1	4.1	4.4
20:4	16	22	35	44	44	52	54	43	2.5	3.0	3.9	4.4	3.9	5.6	5.9
22:4	0.1	0.3	0.3	0.5	0.4	0.7	0.8	0.6	0.02	0.04	0.03	0.05	0.04	0.08	0.08
Σ n-6 PUFA	6200	7600	10000	10800	11800	10900	11300	9200	976	1021	1111	1069	1056	1180	1261
n-3 PUFA															
18:3	680	810	1080	1220	1290	1170	1210	980	107	109	120	121	115	127	134
20:5	10	19	30	32	41	56	55	59	1.6	2.6	3.3	3.2	3.7	6.1	8.1
22:5	5	10	17	22	20	26	27	25	0.8	1.3	1.9	2.2	1.8	2.8	3.4
22:6	24	47	60	63	77	106	106	106	3.8	6.3	6.7	6.2	6.9	11.5	14.5
Σ LC n-3 PUFA	40	76	106	117	138	189	188	191	6.3	10	12	12	12	20	26
Σ n-3 PUFA	720	880	1180	1330	1430	1360	1400	1170	113	118	131	132	128	147	160
Σ PUFA (this study)	6920	8480	11180	12130	13230	12260	12700	10370	1098	1145	1242	1200	1181	1333	1420

[a]All values are expressed as the mean values.
[b]Abbreviations: LC, long chain; LC n-3 PUFA is the sum of 20:5, 22:5, and 22:6; ND, not determined; for other abbreviation see Table 1.

that the comparison of total PUFA intake is within 5% of the PUFA intakes determined in the original NNS analysis (Ref. 15, Table 9).

The results show that adult Australians (age 19+) are consuming on average 10.8 and 0.052 g of LA and AA, respectively, per day. The n-3 PUFA daily intakes were 1.17, 0.056, 0.026, and 0.106 g of LNA, EPA, DPA, and DHA, respectively. Collectively, the LC n-3 PUFA intake was 0.189 g per day and total n-3 PUFA intake was 1.36 g per day (Table 2). However, the median intakes are much lower than the mean intakes (Table 4), as LC n-3 PUFA intake is skewed and not normally distributed. A high proportion of Australians had no intake of the LC n-3 PUFA on the day of dietary data collection, while some people had very high intakes on the day of dietary collection.

Food sources of fatty acid classes are shown in Tables 5–7 inclusive. The major food source contributing to total fat intake (Table 5) is the meat group followed by cereal-based products and milk products. Fish and seafood contribute only 3% of total fat intake, which is slightly lower in adult males (2%) (separate data for male and females are not shown). The main contributor to saturated fat intake (Table 5) is milk and milk products (27%) followed by meat (21%) and cereal-based products (19%). Fish and seafood contribute only 2% of total saturated fatty acid (SFA) intake. The main contributor to monounsaturated fatty acid (MUFA) intake (Table 5) is the meat group (28%) with males (30%) being higher than females (25%) (data not shown). Cereal-based products (19%) and fats and oils (11%), milk and milk products (10%), and vegetable products and dishes (10%) also contribute to MUFA intake. The main contributor to PUFA intake (Table 5) is the fats and oils group (21%) followed by meat (15%), cereal-based products (15%), cereals and cereal products (14%), and vegetable products and dishes (11%). Females obtain less PUFA from meat (14%) compared with males (16%), but they obtain more PUFA from fish and seafood (5%) compared with males (4%) (data not shown).

Table 6 shows the percentage contribution of the different food groups to n-6 PUFA intakes. As expected, fats and oils are the main source of LA, while meat and fish are the major sources of AA.

Table 7 shows the percentage contribution of the different food groups to n-3 PUFA intakes. Cereal-based products and dishes (24%), fats and oils (16%), meat, poultry, and game products and dishes (15%) are the main sources of LNA and total n-3 PUFA intakes. As expected, fish and seafood are the main food source of LC n-3 PUFA (71%), but surprisingly, meat contributed 20% to the intakes of these LC n-3 PUFA.

The relative contribution of total n-6 PUFA, LNA, and the LC n-3 PUFA intakes per food group are shown in Figure 1. While nearly all foods groups listed contribute to the intakes of n-6 PUFA and LNA, only three main food sources contribute to LC n-3 PUFA intakes, namely, fish and seafood, meat, and eggs, with fish and seafood being the major contributor (Fig. 1).

TABLE 3
PUFA Intakes for All Adult Males and Females

	Fatty acid intake (mg/d)						Fatty acid intake [mg/d/energy (MJ)]			
	19+		19–64		65+		19+		65+	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
n	3742	4236	2840	3178	902	1058	3742	4236	902	1058
Energy intake (MJ)	11.0	7.5	ND	ND	8.5	6.4	11.0	7.5	8.5	6.4
n-6 PUFA										
18:2	12800	9100	13200	9400	10500	7900	1158	1216	1234	1241
20:2	8	5	8	5	7	4	0.7	0.7	0.8	0.6
20:3	46	31	47	31	36	29	4	4	4	5
20:4	65	40	68	41	51	36	6	5	6	6
22:4	0.9	0.6	1.0	0.6	0.7	0.4	0.08	0.08	0.08	0.06
Σ n-6 PUFA	12900	9200	13400	9400	10600	7900	1167	1230	1246	1241
n-3 PUFA										
18:3	1380	990	1440	1020	1120	860	125	132	132	135
20:5	66	47	66	46	68	53	6	6	8	8
22:5	32	21	33	21	28	21	3	3	3	3
22:6	124	90	125	89	119	95	11	12	14	15
Σ LC n-3 PUFA	222	159	224	156	214	170	20	21	25	27
Σ n-3 PUFA	1600	1150	1660	1170	1330	1030	145	154	156	162
Σ PUFA (this study)	14500	10350	15060	10570	11930	8930	1318	1380	1403	1395
Σ PUFA[c]	14700	10400	ND	ND	11600	8800	1336	1387	1365	1375
n-6:n-3 ratio	8	8	8	8	8	8	8	8	8	8

[a]All values are expressed as the mean values.
[b]For abbreviations see Tables 1 and 2.
[c]*Source:* Reference 14.

DISCUSSION

This study has estimated the mean adult Australian intake of total fat as 76 g per day of which 32 g is saturated fat, 27 g monounsaturated fat and 12.2 g polyunsaturated fat. This compares favorably with intakes reported in the original analysis of the NNS (15) using NUTTAB95. Until recently, the supporting Australian nutrient software program did not allow for the determination of individual fatty acids, such as the n-6 and n-3 PUFA. However, with the development of a database of fatty acid composition of Australian foods (12), it is now possible to accurately assess the intake levels of individual fatty acids in the Australian population. This study shows that the mean adult Australian n-6 PUFA intake is 10.9 g per day of which 10.8 g is LA and 0.052 g is AA. The mean Australian n-3 PUFA intake is 1.36 g per day of which 1.17 g is LNA and 0.189 g is LC n-3 PUFA. These results compare favorably with an earlier estimation that determined the mean or median intakes of total n-6 PUFA, LNA, LC n-3 PUFA, and total n-3 PUFA to be 9.9, 1.01, 0.180, and 1.2 g, respectively (11). However, the median intakes show that 50% of the population is consuming no more than 0.029 g of LC n-3 PUFA, which is comparable to the mean estimated intakes (0.039 g of LC n-3 PUFA) of adolescents in Rhode Island (16) but falls well short of the range of recommendations mentioned in the Introduction and the current Japanese intake of 1.6 g per day (3). It appears that older Australians are consuming nearly twice as much LC n-3 PUFA [mg/d/energy (MJ)] as that of persons aged 18 years and younger (Table 2), probably due to the adults consuming more fish and seafood products and dishes (15).

As highlighted in the introduction, there appear to be conflicting recommendations regarding the recommended daily intake (RDI) of PUFA. The rationale for decreasing our intakes of n-6 PUFA is to maximize the utilization of n-3 PUFA, as LA and LNA compete for the same desaturase and elongase enzymes (17,18). Moreover, it has been shown more recently that the incorporation of LC n-3 PUFA into membranes depends on the background fatty acid intake (19,20). For example, the LC n-3 PUFA are incorporated into membrane phospholipids to a

TABLE 4
The Mean and Median Intakes of PUFA by Australian Adults (≥19 yr old)[a]

Fatty acid	Mean intakes	Median intakes	Median/mean (%)
n	10,851	10,851	
n-6 PUFA			
18:2	10.8	9.0	83
20:2	0.006	0.001	10
20:3	0.039	0.008	20
20:4	0.052	0.024	46
22:4	0.001	0.000	0
Σ n-6 PUFA	10.9	9.01	83
n-3 PUFA			
18:3	1.17	0.95	81
20:5	0.056	0.008	14
22:5	0.026	0.006	23
22:6	0.106	0.015	14
Σ LC n-3PUFA	0.189	0.029	15
Σ n-3 PUFA	1.36	1.08	74
Total PUFA	12.24	10.28	84

[a]For abbreviations see Tables 1 and 2.

TABLE 5
Food Sources for Total Fat (TF), Saturated Fatty Acids (SFA), Monounsaturated Fatty Acids (MUFA), and PUFA for All Persons (≥19 yr old)

Major food group name	TF	SFA	MUFA	PUFA
		(%)		
Meat, poultry, and game products and dishes	23.10	21.26	27.88	15.20
Cereal-based products and dishes[a]	18.27	19.11	19.09	15.23
Milk products and dishes	18.04	27.48	10.01	4.03
Vegetable products and dishes	8.94	6.96	9.80	11.23
Fats and oils	8.84	9.13	11.22	20.87
Cereals and cereal products[b]	6.73	3.33	4.96	13.70
Savory sauces and condiments	2.73	1.71	3.14	4.66
Seed and nut products and dishes	2.57	1.04	3.42	4.73
Fish and seafood products and dishes	2.55	1.80	2.60	4.44
Confectionery and health bars	2.31	3.20	1.92	0.75
Egg products and dishes	2.20	1.64	2.57	1.73
Soup	1.22	1.10	1.21	1.14
Snack foods	1.13	1.25	1.37	1.15
Nonalcoholic beverages	0.48	0.43	0.21	0.05
Fruit products and dishes	0.37	0.11	0.17	0.19
Legume and pulse products and dishes	0.27	0.12	0.20	0.73
Sugar products and dishes	0.09	0.16	0.11	0.07
Miscellaneous	0.08	0.11	0.07	0.05
Alcoholic beverages	0.05	0.07	0.04	0.01
Special dietary foods	0.01	0.01	0.02	0.02

[a]These foods include biscuits, cakes, pies, fried rice, pizza, vol-au-vents (puff pastry), quiche, gnocchi, lasagna, commercial hamburgers, croissants, and pancakes (15).
[b]These foods include bread, muffins, rice, pasta, and breakfast cereals (15). For other abbreviation see Table 1.

greater extent if the background intakes of fatty acids are primarily monounsaturated with limited intake of n-6 PUFA (19). This may have implications for subsequent eicosanoid production, as eicosanoids produced from the n-6 PUFA AA have mainly vasoconstrictor, pro-aggregatory, and pro-inflammatory actions, whereas eicosanoids produced from n-3 PUFA EPA result in primarily vasodilation and anti-inflammatory actions (21,22). Hence, there is a necessity to balance these fatty acids in our cell membranes, which can be achieved by modifying dietary intakes.

Our Paleolithic ancestors consumed much higher intakes of n-3 PUFA compared with our current intakes. It is estimated that the diet of Paleolithic hunter-gatherers contained 8.8 g/d of LA and 12.6 g/d of LNA, giving an n-6/n-3 PUFA intake ratio of approximately 0.7 for the 18-carbon length PUFA (23). Their LC PUFA intakes were estimated to be 1.8 g/d for AA and 1.1 g/d for LC n-3 PUFA, giving an n-6/n-3 ratio for LC PUFA of 1.6. The total n-6 and n-3 PUFA intakes were 10.6 g/d and 13.7 g/d, respectively, giving an overall n-6/n-3 PUFA intake ratio of 0.8 (23). This ratio is much lower than our estimate of 8:1 for the n-6/n-3 PUFA intake ratio reported in this study. If we were to readdress the balance, we need either to reduce the n-6 PUFA intake or to increase the n-3 PUFA intake or both.

Given that our Paleolithic ancestors consumed approximately 1.1 g of LC n-3 PUFA per day (23), Greenland Eskimos consume 14% of total fatty acids as LC n-3 PUFA per day (24), and Japanese consume 1.6 g per day (3), it should be possible to substantially increase our LC n-3 intake. Epidemiological evidence links high intakes of LC n-3 PUFA to longevity (25), and experimental evidence shows that taking <1 g of LC n-3 PUFA per day can reduce total death, nonfatal myocardial infarction, and stroke in people with recent (<3 mon) myocardial infarction (26).

On the other hand, the American Heart Association and the National Heart Foundation (NHF) of Australia (6) recommend doubling our current intakes of n-6 PUFA from 5% to

TABLE 6
Food Sources for the n-6 PUFA

Major food group name	18:2	20:2	20:3	20:4	22:4	Σ n-6
				(%)		
Meat, poultry, and game products and dishes	14.94	86.46	23.97	70.15	11.14	15.27
Cereal-based products and dishes[a]	14.73	0.41	9.87	1.00	0	14.64
Milk products and dishes	3.18	0.01	0	0.12	0	3.16
Vegetable products and dishes	11.64	1.50	0	0	0	11.54
Fats and oils	21.85	6.52	0	0	0	21.66
Cereals and cereal products[b]	14.15	1.67	1.13	0.24	0	14.03
Savory sauces and condiments	4.87	0.01	0	1.13	0	4.84
Seed and nut products and dishes	5.38	0	0	0	0	5.33
Fish and seafood products and dishes	3.24	2.90	2.04	27.21	88.62	3.36
Confectionery and health bars	0.84	0	0	0	0	0.83
Egg products and dishes	1.58	0.04	62.93	0.16	0.24	1.78
Soup	1.23	0	0.06	0	0	1.22
Snack foods	1.29	0.40	0	0	0	1.28
Nonalcoholic beverages	0.04	0	0	0	0	0.04
Fruit products and dishes	0.20	0.04	0	0	0	0.20
Legume and pulse products and dishes	0.69	0.04	0	0	0	0.69
Sugar products and dishes	0.07	0	0	0	0	0.07
Miscellaneous	0.04	0	0	0	0	0.04
Alcoholic beverages	0.01	0	0	0	0	0.01
Special dietary foods	0.02	0	0	0	0	0.02

[a]These foods include biscuits, cakes, pies, fried rice, pizza, vol-au-vents (puff pastry), quiche, gnocchi, lasagna, commercial hamburgers, croissants, and pancakes (15).
[b]These foods include bread, muffins, rice, pasta, and breakfast cereals. For abbreviation see Table 1.

TABLE 7
Food Sources for the n-3 PUFA

Major food group name	18:3	20:5	22:5	22:6	Σ LC[c]	Σ n-3[c]
			(%)			
Meat, poultry, and game products and dishes	15.26	20.58	49.21	11.77	19.6	15.86
Cereal-based products and dishes[a]	23.8	0.15	0.40	4.35	2.55	20.85
Milk products and dishes	11.40	0	0	0	0	9.82
Vegetable products and dishes	9.81	2.22	0	0	0.66	8.54
Fats and oils	16.31	0	0	0	0	14.05
Cereals and cereal products[b]	12.86	0.05	0	0.33	0.20	11.10
Savory sauces and condiments	3.54	0	0	0.37	0.21	3.08
Seed and nut products and dishes	0.43	0	0	0	0	0.37
Fish and seafood products and dishes	3.54	75.87	50.36	73.12	70.78	12.86
Confectionery and health bars	0.53	0	0	0	0	0.46
Egg products and dishes	0.55	1.12	0.04	10.02	5.98	1.30
Soup	0.30	0	0	0.01	0.01	0.26
Snack foods	0.10	0	0	0	0	0.09
Nonalcoholic beverages	0.18	0	0	0	0	0.15
Fruit products and dishes	0.16	0	0	0	0	0.14
Legume and pulse products and dishes	1.01	0	0	0.03	0.02	0.87
Sugar products and dishes	0.08	0	0	0	0	0.07
Miscellaneous	0.08	0	0	0	0	0.07
Alcoholic beverages	0.04	0	0	0	0	0.03
Special dietary foods	0.03	0	0	0	0	0.02

[a]These foods include biscuits, cakes, pies, fried rice, pizza, vol-au-vents (puff pastry), quiche, gnocchi, lasagna, commercial hamburgers, croissants, and pancakes (15).
[b]These foods include bread, muffins, rice, pasta, and breakfast cereals.
[c]Σ LC is the sum of 20:5, 22:5, and 22:6; Σ n-3 is LNA and Σ LC; for other abbreviations see Table 1.

8–10% of total energy. The rationale is that, when saturated fat is replaced by n-6 PUFA in the diet, the risk of coronary heart disease decreases (6). However, the decreased risk is attributable to the reduction in saturated fat; increasing the consumption of n-6 PUFA without a concomitant decrease in saturated fat has not been shown to be of benefit. Importantly, the resultant displacement of n-3 PUFA from membranes by n-6 PUFA may produce an undesirable imbalance in precursors of eicosanoid production (18,20,27).

In terms of food sources, our study has shown that males eat more meat than females; hence, they have greater intakes of SFA, MUFA, and PUFA from meat, including the LC n-3 PUFA (22 vs. 16% for males and females, respectively). As females eat more fish (as a percentage of total energy) than

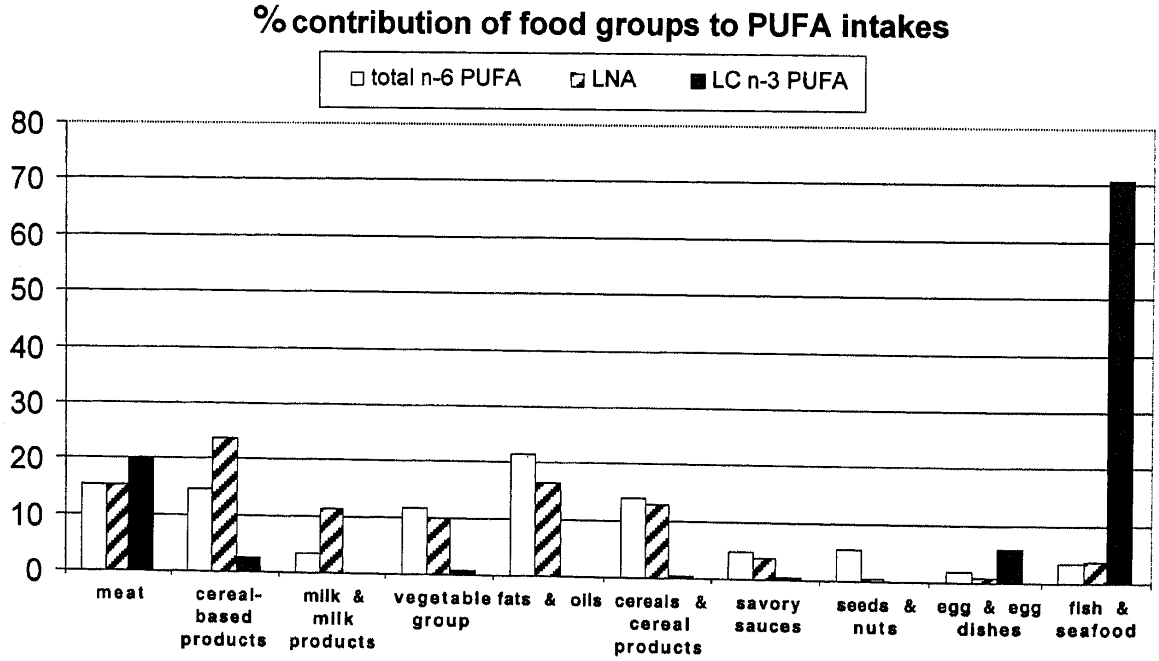

FIG. 1. The percentage contribution of the different food groups to PUFA intakes by adult Australians (>19 yr). Abbreviations: PUFA, polyunsaturated fatty acid; LNA, linolenic acid; LC n-3 PUFA, 20:5n-3, 22:5n-3, and 22:6n-3.

males, they obtain 74% of LC n-3 PUFA from fish, whereas males obtain 68% LC n-3 PUFA from fish. However, a great proportion of people do not consume fish or seafood products at all. Another way to increase the consumption of n-3 PUFA is to consume foods that have been fortified with the LC n-3 PUFA. Such foods may meet the criteria for the n-3 nutrition claim.

The former Australia New Zealand Food Authority, now known as Food Standards Australia New Zealand (FSANZ), recently introduced criteria in the Food Standards Code for voluntary nutrition claims in relation to the omega fatty acid content of foods (28). Nutrition claims in relation to n-3 PUFA content of a food, "other than fish or fish products that have no added saturated fatty acids," must not be made "unless the total of saturated fatty acids and *trans* fatty acids is less than 28 percent of the total fatty acid content of food; or the food contains no more than 5 g of saturated fatty acids and *trans* fatty acids per 100 g of the food" (28). Further, a claim that a food is a "source" of n-3 PUFA must not be made unless the food also "contains no less than 200 mg α-linolenic acid per serving or 30 mg total EPA and DHA per serving," whereas for a claim of a "good source" of n-3 PUFA, the food must contain no less than 60 mg total EPA and DHA per serving (28). Members of the food industry wishing to produce food products containing n-3 PUFA can utilize the n-3 nutrition claim and consumers will have more of a choice regarding food sources of LC n-3 PUFA. One may hope that this increased food choice will translate into increased consumption of LC n-3 PUFA.

In summary, adult Australians are consuming 10.8 g LA, 0.052 g AA, 1.17 g LNA, 0.056 g EPA, 0.026 g DPA, 0.106 g DHA, and collectively the LC n-3 PUFA of 0.189 g per day. The total n-6 PUFA is 10.9 g per day, and the total n-3 PUFA intake is 1.36 g per day. The mean n-6 PUFA intakes compare favorably to the recommendations by the NHMRC of Australia but fall short of NHF of Australia (6) and U.S./Canadian (8) recommendations and far exceed those recommendations by Simopolous *et al.* (5) (Table 1). The mean LNA intake is comparable to the U.S./Canadian recommendations but is approximately half the recommended intakes by the other organizations (Table 1). The mean LC n-3 PUFA intake compares favorably to some recommendations (4,6,8) but falls short of other international recommendations (2,5–7), especially the Japanese intakes of 1.6 g per day (3) (Table 1). The main food sources for n-6 PUFA include the fats and oils group, meat, cereals and cereal-based products, and vegetable products and dishes, while the main food sources for n-3 PUFA include cereal-based products and dishes, fats and oils, meat, poultry, and game products and dishes. The main food sources for the LC n-3 PUFA are fish and seafood, followed by meat and eggs.

In conclusion, we have identified intakes and food sources of both n-6 and n-3 PUFA for the Australian adult population. Our intakes of LC n-3 PUFA could be increased and this may be achieved by the introduction of foods fortified with LC n-3 PUFA.

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