Summary and recommendations

Robert A Gibson, Maria Makrides and Coral G B Colyer

NUTRITION IS NO LONGER just the science of avoiding deficiencies, but rather is now focused on determining the levels of dietary nutrients that will optimise physiological and health outcomes. Nowhere is this change in the study of nutrition more evident than in the study of dietary fatty acids.

In a few short years we have progressed from the simple mantra "saturates are bad, polyunsaturates are good" to a far more sophisticated understanding of the way that individual fatty acids in our foods can manifest physiological change. We now know that not all saturated fatty acids cause a rise in plasma cholesterol levels — some are more atherogenic than others, which explains why some food fats cause a larger rise in plasma cholesterol levels than others. So, foods rich in saturates should still be avoided, but dietary advice can now be more targeted.

Equally important is that we have also come to realise that not all polyunsaturated fatty acids (PUFAs) are equal. Nutritionists now differentiate between omega-6 and omega-3 PUFAs, not only because their chemical structures differ, but also because they elicit different effects. Omega-6 PUFAs, for so long a common constituent of a huge variety of spreads, cooking oils and foods, have proven their worth in numerous studies on cholesterol lowering. However, some key studies conducted over the past 10 years have shown the potency of foods containing omega-3 PUFAs. The improved survival of people who had already experienced a cardiac event when they consumed diets rich in omega-3 PUFAs was remarkable. Whether the omega fatty acids were vegetable in origin[1] or were marine oils,[2] all-cause mortality rates were reduced by 30%–70% and induced comparable large reductions in non-fatal sequelae. These results were equivalent to effects seen in statin trials. In addition, the protective effect of the Mediterranean dietary pattern in the Lyon study[1] was maintained up to four years after the first infarction, confirming the previous intermediate analyses and demonstrating the sustainability of this type of diet. Major traditional risk factors, such as high total blood cholesterol level and raised blood pressure, continued to be independent and joint predictors of recurrence, indicating that the diet did not alter, at least qualitatively, the usual relationships between major risk factors and recurrence, but provided additional protection. Given the low risk and low cost of this type of intervention, it seems vital that the usefulness of dietary intervention in secondary prevention be fully realised.

There have also been breakthroughs in the use of omega-3 PUFAs in preterm infant nutrition. Because of our limited ability to convert vegetable omega-3 PUFAs to the long-chain PUFA found in marine foods (such as docosahexaenoic acid [DHA]), several clinical trials have tested the effectiveness on short- and long-term development of supplementing formulas with DHA. The results have been consistently positive, highlighting the fact that fats are essential to the normal growth and development of children. Here, the mechanism may seem to be self-evident, as DHA is a major component of brain and retina, and the preterm infant is denied the natural flow of DHA from the mother, which is greatest in late pregnancy. However, the actual role of DHA in these tissues is still being unravelled. Importantly, change has occurred in the market place, and all preterm infant formulas sold in Australia are now supplemented with DHA.

There are a number of clinical areas where omega-3 PUFAs in the diet have shown promising results. Benefits have been well documented in down-regulating inflammatory responses in cells and animals, and these results are being translated into an effective treatment for some inflammatory conditions such as rheumatoid arthritis. Some inconsistencies between trial results may be due to the time between disease onset and treatment. Certainly, this disease has a lower incidence in fish-eating cultures, and a higher consumption of omega-3 PUFAs in the national diet may help prevent disease onset.

There are a number of challenges for the future. The mechanism of action of many dietary fatty acids is still not fully clear, and their interaction with existing drug therapies needs to be defined. There is no doubt that many effects of fatty acids are mediated by regulation of gene expression.

The real challenge for this decade is to quantify the effectiveness of primary prevention programs based on increased omega-3 intakes. After all, this is the area where the most public health benefit is to be gained, keeping people out of hospitals and ensuring the maximum number of healthy years to us all.

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Recommendations

The following recommendations are provided to guide medical and allied health professionals working with people at all stages of the lifecycle.

1: Suggested healthy fats menu plan for adults*

Breakfast	Lunch	Dinner
Wedge of rockmelon or paw-paw	Pasta with tomatoes, *soy* or cannellini beans, capsicum, mushrooms and basil	Fillet of *fish,* pan-cooked with a little olive oil, herbs and lemon
Wholegrain or bran cereal or *muesli* or oats with low-fat milk	(optional: top with a small can of *salmon* or *tuna*)	Baked potato wedges
Soy and linseed toast with *canola spread* topped with ricotta and tomato slices	Mixed green salad with *flaxseed* vinaigrette dressing	Steamed green beans or zucchini (large serve) with *toasted walnuts*

Between meals

Choose from:

- Vegetable or minestrone soup
- 2–3 sushi rolls with *salmon* or *tuna* or *prawn*
- Fresh fruit or fruit salad
- ¼ cup *walnuts* or *pecans*
- Raisin toast with *canola spread*
- 2–3 rice cakes with *canola spread*, sliced banana and honey
- Carton of low-fat fruit yoghurt
- ½ avocado
- Low-fat muesli or breakfast bar

*Foods in italics are sources of omega-3 fats.

Pregnancy and the first year of life

- The strongest evidence for good developmental outcomes for infants is breastfeeding for at least 6 months.
- Fish-oil supplementation during pregnancy has been tested in several trials, with small positive effects on length of gestation.
- There have been no beneficial or harmful effects on cognitive development or growth of infants as a result of fish-oil supplementation in pregnancy.
- Preterm infants are at the greatest risk of DHA deficiency, and there is evidence for the use of breast milk and DHA-supplemented formulas for positive effects of DHA on visual and cognitive outcomes.
- Debate continues about the importance of DHA supplementation for term infants. The current consensus is that the benefits of DHA supplementation for term infants are smaller than for preterm infants.

Toddlers to preschool

- Toddlers need to be continually encouraged to try a wide range of foods supplying all types of fats, and with the emphasis on nutrient-dense foods.
- Reduced-fat products are not appropriate for toddlers when the particular food forms a substantial part of their intake.
- No sound evidence exists to support the manipulation of dietary fat for the treatment of attention deficit hyperactivity disorder or the prevention or treatment of asthma.

Primary school

- Fats are essential to the normal growth and development of children.
- Parents need to understand that the most significant influence on a child's eating patterns are their own eating patterns and preferences.
- The recommendation of 30% total energy from fat can be achieved by practical changes in eating patterns. This may include limiting high-fat and high-saturated-fat snack foods, like ice cream and potato chips, to occasional or treat items.

Adolescence and young adulthood

- Advice supporting regular physical activity, healthy food choices and smoking avoidance is definitely warranted in adolescents.
- The amount of dietary fat is important in maintaining energy balance and the type of fat is important in reducing the development of heart disease.
- Low fat foods are suitable, but it is also important to avoid sources of "hidden" saturated fatty acids (biscuits and fast foods) and to include sources of polyunsaturated and monounsaturated fatty acids (oils, margarine, lean meat and poultry and nuts).

Adulthood — prevention

Cardiovascular disease

- To achieve a more desirable ratio of dietary omega-3 to omega-6 PUFAs, encourage the consumption of fish and omega-3-rich seed oils and spreads, such as canola, soy and flaxseed.
- A diet that is rich in PUFAs, such as omega-3, and low in saturates, should be encouraged. This type of diet is rich in fish, whole-grain cereals, fruits and vegetables and low-fat dairy foods. Refer to the Box for a sample menu plan.

Rheumatoid arthritis

- There is evidence for preventive and therapeutic effects of dietary omega-3 fats in rheumatoid arthritis.

Diabetes

- Total fat intake is not related to the risk of diabetes. However, polyunsaturated fat reduces the risk, monounsaturated fat is neutral, and saturated fat may increase the risk. However, body weight is a more critical predictor than macronutrients in the diet.
- Putting this into practice for adults

A suggested "healthy fats" meal plan for adults is provided in the Box, which aims to:

- minimise saturated fat intake;
- incorporate monounsaturated and polyunsaturated fats in moderate quantities from oils, spreads, nuts, seeds and avocado;

- include sources of omega-3 fats (see Box);
- be high in fibre; and
- offer generous amounts of vegetables and fruits, whole grains, and low fat dairy foods.

Adulthood — treatment

Cholesterol-lowering with plant sterols

- Margarines enriched with plant sterols should be considered for patients with increased cardiovascular risk factors, in whom low-density lipoprotein level reduction is desirable.
- Phytosterol-containing foods are valuable additions to other cholesterol-lowering treatments, including statins.
- Encourage the consumption of an additional serving of carotenoid-rich fruit or vegetable (eg, rockmelon, mangoes, carrots, pumpkin) to overcome the possible reduction in some carotenoids in plasma.

References

1. De Lorgeril M, Salen P, Martin JL, et al. Mediterranean diet, traditional risk factors and the rate of cardiovascular complications after myocardial infarction. *Circulation* 1999; 99: 779-785.
2. GISSI-Prevenzione Investigators. Dietary supplementation with n-3 polyunsaturated fatty acids and vitamin E after myocardial infarction: results of the GISSI-Prevenzione trial. *Lancet* 1999; 354: 447-455. ❑

Background

The renaissance of fat: roles in membrane structure, signal transduction and gene expression

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Summary

- The intracellular and intramembrane profiles of fatty acids mirror those of dietary fat intake.
- The properties of transporter and receptor proteins embedded within cell membranes are influenced by the composition of the phospholipid membrane of cells.
- Many cell-signalling pathways involve lipids or lipid-derived molecules.
- Specific fatty acids are increasingly being identified as key regulators of gene expression and tissue differentiation.

IN RECENT YEARS, it has become clear that fat has a role beyond that of macromolecular energy storage. Indeed, fat participates in intracellular processes as diverse and complex as membrane fluidity, signal transduction and the regulation of gene expression. Furthermore, as specific fats are involved in mediating these effects, the profile of dietary intake assumes vital importance, especially as humans cannot make several of the key lipids themselves.

Fatty acids and membrane function

All cell membranes consist of a bilayer of phospholipids. The membrane is impermeable to charged molecules, so, for communication between cells and compartments to occur, specific protein transporters or receptors have to be embedded in the bilayer. The bilayer is fluid and flexible, allowing free lateral movement of the proteins and the formation of invaginations to permit the processes of endocytosis and exocytosis.

Crucially, the length and degree of saturation of the fatty acids in the membrane phospholipids determines the fluidity of the membrane. Long (> 16 carbons) and saturated fatty acyl groups tend to make the membrane less fluid, whereas shorter, unsaturated fatty acids permit greater flexibility and permeability. The functionality of proteins in the membrane is critically dependent on membrane fluidity, especially when the proteins have to collide with other molecules to exert their effects (as in many receptor-mediated pathways) or when the proteins have to be endocytosed (such as the ingestion of low-density lipoproteins [LDLs] after binding to the LDL-receptor).

It is vital that a variety of fatty acids be available for membrane phospholipid construction. Many of the fatty acids in membranes are unsaturated and cannot be made by humans *de novo*. These include alpha-linolenic acid and linoleic acid. Therefore, the mix of fatty acids in the diet can have profound effects on the membrane phospholipid fatty acid composition and on the efficiency of membrane-mediated processes. For example, the ability of insulin to communicate its signal is strongly impaired when animals are fed a diet high in saturated fat and this effect can be overcome with omega-3 poyunsaturated fatty acid intake. This, in turn, is probably related to diet-induced changes in membrane fatty acid profile, as recent studies have shown strong correlations between membrane phospholipid composition and insulin sensitivity in humans.[1]

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