Dairy products and fish intake and the progression of type 2 diabetes: an update of the evidence

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Abstract
In general, replacement of saturated fat with monounsaturated and polyunsaturated fat reduces the risk of type 2 diabetes, with the evidence stronger for polyunsaturated fat. However, recent research studies have highlighted the importance of the source of dietary fat in prevention of type 2 diabetes. For example, saturated fats found in dairy products are associated with a reduction in risk in large epidemiological studies. Similarly, while polyunsaturated fats in vegetable oils and nuts appear to reduce the risk of type 2 diabetes, polyunsaturated fats in fish do not.

This article will review the evidence for dairy products and fish in prevention of type 2 diabetes, with attention paid to risk factors such as insulin sensitivity, secretion and adiposity. The evidence suggests that consumption of low-fat dairy products can protect against type 2 diabetes, while the effect of full-fat dairy appears to be neutral. Oily and white fish have no independent effect on the risk of type 2 diabetes but their consumption is associated with a healthy body weight. Copyright © 2016 John Wiley & Sons.

Key words
yoghurt; cheese; milk; calcium; omega-3

Introduction
The role of dietary fat in the development of type 2 diabetes (T2D) has been of interest for decades, partly given its previously posited role in weight management, and the casual relationship between body weight and T2D. While it now appears that low-fat diets are no more effective than other approaches to lose weight, dietary fat is still relevant for T2D prevention and management due to its role in insulin signalling and sensitivity. From a broad nutrient perspective, replacement of saturated with unsaturated fat appears to reduce T2D risk, and prevent cardiovascular disease (CVD). However, nutrients are of course consumed as foods, and it is now clear the source of dietary fat is an important consideration. This article will review the evidence on two sources of dietary fat – dairy products and fish – on prevention of T2D.

Dairy products
Dietary guidelines have generally promoted the consumption of low-fat varieties of dairy products due to the concerns that the high saturated fat content is associated with increased risk of CVD, and that high-fat varieties of food may promote weight gain and, as a consequence, T2D. Palmitic acid (C18:0) is the dominant saturated fatty acid (SFA) in animal fat and, alongside other even-chain SFAs, largely determines the LDL-cholesterol raising effect of dietary saturated fat. In addition, dairy products also contain odd-chain SFAs along with naturally-occurring trans fatty acids (trans palmitoleic acid).

Observational studies
Several large observational studies have shown that circulating fatty acids from dairy products have an inverse association with T2D, leading to suggestions that dairy fat per se may be beneficial. There are important caveats to this suggestion. Firstly, circulating odd-chain fatty acids are a useful qualitative, but not necessarily quantitative, marker for dairy intake. Secondly, most studies examining the relationship between reported dairy intake and T2D find that only low-fat dairy is significant or that, while total dairy is inversely related, the relationship is stronger with low fat.
Interestingly, the type of dairy product may also influence this relationship, with fermented dairy such as fermented yoghurt or cheese negatively associated with T2D incidence in some studies.12,14

Randomised controlled trials
There are no long-term trials with T2D incidence as an outcome. Randomised controlled trials have not found consistent effects on surrogate markers of risk such as glucose concentrations or insulin sensitivity. Six weeks’ consumption of ~470ml 2% milk and 170g low-fat yoghurt had no within-group effect on glucose or insulin parameters;15 whereas six months of four servings per day (a serving = 175g low-fat yoghurt or 250ml low-fat milk) improves insulin resistance compared to two servings per day.16 A 24-week calorie-reduced diet supplemented with three servings of dairy per day significantly increased insulin sensitivity compared to a calorie-reduced diet supplemented with calcium only. However, the dairy-supplemented diet also resulted in greater weight loss, making the results challenging to interpret.17 A recent well-designed study showing that four weeks of four to six servings per day of low-fat dairy impairs insulin sensitivity also urges caution.18

Potential mechanisms
Calcium. While observational studies in general support a role for calcium (whether dietary or from supplements) in the prevention of T2D, the results are not completely consistent.19,20 Furthermore, observational studies may be confounded by the association between calcium and other beneficial nutrients such as vitamin D and magnesium.19,20 The results from controlled trials are mixed21–25 and likely depend on habitual calcium intake and dose of supplementation. There is little evidence of benefit of amounts exceeding the recommended UK intake.21–25 There is no evidence that calcium has any effect on insulin secretion, and any benefits appear limited to improving insulin sensitivity.21–25

Dairy proteins. Casein and whey are the predominant proteins in milk. There are >20 controlled trials investigating the effect of whey and casein or a combination of the two on glucose homeostasis in people with and without T2D.24–26 In general, these studies demonstrate that whey and/or casein lower postprandial glucose concentrations, an effect at least partly due to increased insulin secretion.24–26 Although the average dose of whey given in these studies was above that which could be achieved from milk alone, the lowest effective dose of casein on insulin secretion was 12g which is achievable through diet.27 The effect on insulin secretion is particularly important since a loss of first-phase insulin secretion is a critical defect in the pathophysiology of T2D.29 Taken together, these studies provide compelling in vivo evidence that dairy proteins can significantly improve aspects of glucose homeostasis.

Fermented products. Menaquinones are one of two biologically active forms of vitamin K and are found in dairy products such as milk or cheese as a product of bacterial fermentation.30 Menaquinone intake is inversely associated with insulin resistance in cross-sectional studies,31 and supplementation of vitamin K in amounts attainable in the diet may reduce insulin resistance.32

Probiotics. The gut microbiota has been implicated in metabolic health and disease and can be modified by the diet.33 Probiotics are live microorganisms that, when administered in adequate amounts, confer a health benefit on the host.34 Microorganisms such as Lactobacillus bulgaricus and Streptococcus thermophilus are used in the production of yoghurt, but other species of probiotics are added by the manufacturer either during or after culturing. A recent meta-analysis suggests some probiotics have beneficial effects on glucose concentrations in people with and without T2D35 which could partly explain the inverse relationship between yoghurt and T2D in cohort studies. However, only yoghurt supplemented with vitamin D reduced glucose and insulin concentrations in patients with T2D; yoghurt without vitamin D had no effect.36 In contrast, yoghurt supplemented with additional probiotics (Lactobacillus acidophilus and Bifidobacterium animalis) attenuated changes in insulin sensitivity in pregnant women.37 This may suggest that only specific species or subspecies would be beneficial, which warrants further study.

Body weight and adiposity. BMI is positively related to T2D incidence.38 Dairy consumption is associated with lower body weight in population studies.39 Randomised controlled trials suggest dairy and its components may help lower adiposity only in the context of energy restriction.40,41 Additionally, dairy products – particularly the low-fat varieties – are low-energy-dense, and associated with healthy dietary patterns both of which are inversely associated with T2D risk.52,43

Dairy: the bottom line
Overall, the data suggest that consumption of low-fat dairy in particular can reduce the risk of T2D by a variety of mechanisms. This is reflected in current national and international guidelines which recommend dairy consumption for the prevention of T2D.44,45 Dairy products also contain a variety of nutritive and non-nutritive components beneficial for health and are a rich source of minerals which are under-consumed by all age groups in the UK, including potassium, magnesium and calcium.46 The effect of full-fat dairy on T2D risks is probably neutral.

Fish
In culinary terms, fish is divided into two types: white fish and oily fish. While white fish typically has fewer than 1% of calories from fat, oily fish such as salmon or mackerel has 7% fat, of which 30% comes from the two main omega-3 (n-3) polyunsaturated fats (PUFA): eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Much of the interest in oily fish and cardiometabolic disease comes from early population studies,47 demonstrating an inverse relationship between oily fish and coronary heart disease; and a large body of controlled trials demonstrating clinically significant effects on surrogate markers of CVD risk.
Since people with and at risk of T2D have a higher risk of CVD, consumption of oily fish twice a week forms an important part of a healthy dietary pattern.

This section will review the evidence for the role of fish in the prevention of T2D.

Observational studies

Data from observational studies are inconsistent.48,49 Even where studies have found an association between fish intake and T2D risk, the relationship is not independent of BMI or waist circumference.49 This suggests that consumption of white or oily fish can form part of a healthy dietary pattern which itself is associated with low body weight and adiposity. In contrast, in countries where fish is commonly fried, consumption of fish may even increase the risk of T2D.50

Prospective studies demonstrate no role for reported n-3 intake on insulin sensitivity or T2D risk.2 A number of these studies have measured muscle or adipose DHA and EPA composition as biomarkers for intake. Long-chain PUFAs cannot be synthesised by the body, and thus the presence of EPA and DHA in the body can serve to strengthen observations from self-reported intake.2

In fact, the strength of the evidence from observational studies demonstrates that it is the omega-6 (n-6) fatty acids which are inversely associated with T2D incidence.51 The n-6 composition of skeletal muscle,51 the intake of n-6 PUFAs (primarily linoleic acid)32 and the ratio of dietary PUFA:SFA intake53 are all negatively associated with HbA1c or T2D in multiple prospective cohort studies.

Controlled trials

There are no studies on fish intake with T2D as an endpoint. A systematic review of 20 randomised controlled trials on the role of n-3 in T2D concluded that n-3 fatty acids have no effect on glucose homeostasis whether measured as fasting plasma glucose, postprandial glucose or HbA1c.54,55 Of concern, high doses of n-3 (~6g DHA/EPA per day) may impair insulin action in people with T2D.55

Mechanisms

Although neither observational nor prospective trials demonstrate a role for omega-3 on T2D risk, it is worth reviewing the proposed mechanisms to determine where the evidence stands.

Inflammation. A commonly stated reason for the proposed beneficial effect of n-3 fatty acids is that they are anti-inflammatory whereas PUFAs from the n-6 class are pro-inflammatory, by virtue of their in vivo metabolic pathways.56 There is no convincing evidence from human studies that n-6 (predominantly linoleic acid) has any detrimental effects on inflammation,2 with some well-controlled studies suggesting that linoleic acid reduces so-called inflammatory markers, compared to saturated fat from butter.57

Regulation of adiposity. There are intriguing data from controlled trials showing that n-3 supplementation from ~6g/day can lower adiposity, including deposition of intrahepatic triglyceride, potentially via relation of genes involved in fat oxidation.38,39 Nevertheless, such effects have been demonstrated at intakes reflecting habitual and recommended consumption of oily fish,38 putting into question the rationale for further consumption above these levels without clear clinical justification.

Low energy-dense diets are negatively associated with body weight and adiposity.42,43 and consumption of one 6oz fillet of white fish such as cod provides <2000kcal, whereas the same weight of salmon provides ~390kcal. In contrast, a beef-burger made from lean mince can provide >500kcal. Therefore, fish can form part of a dietary pattern likely to help maintain a healthy body weight.

Key points

- Consumption of low-fat dairy, such as skinned or semi-skinned milk, and low-fat yoghurt appears to be protective against type 2 diabetes
- There is not sufficient evidence to recommend high-fat dairy as protective against type 2 diabetes, but it does not appear to increase risk
- Oily and white fish do not specifically reduce the risk of type 2 diabetes but their consumption should be encouraged as part of a healthy balanced diet

Fish: the bottom line

The consumption of n-3 essential fatty acids from oily fish forms part of a healthy diet and is particularly important for CVD prevention.

However, there is not convincing evidence that further consumption of n-3 in the form of supplements confers greater risk reduction for CVD, and this is reflected in the updated National Institute for Health and Care Excellence guidelines for lipid management.

Furthermore, there is no evidence that fish per se, including oily fish, has any effect on T2D risk.

Conclusions

Despite frequent newspaper headlines implying that dietary guidelines have been retracted or overhauled, in practice nutritional science should move slowly and cautiously.

The evidence suggests that low-fat dairy is protective against T2D. There is not currently sufficient evidence to recommend high-fat dairy as protective. Nevertheless, there is also no evidence suggesting that high-fat dairy increases the risk of T2D, and therefore its consumption should be considered in the balance of a healthy nutrient-rich diet.

Both white and oily fish should be encouraged as part of a healthy balanced diet, and may help maintain a healthy body weight and fat distribution. There is no evidence to suggest that white or oily fish consumption specifically protect against type 2 diabetes.

Declaration of interests

There are no conflicts of interest declared.

References

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