Recommended Nordic diet and risk markers for cardiovascular disease

BACKGROUND Cardiovascular diseases are among the main causes of morbidity and mortality in Norway. The objective of this article is to provide an overview of literature that describes the effect of a Nordic diet in line with the authorities' dietary advice on risk factors for cardiovascular disease.

METHOD Electronic literature searches were undertaken in the PubMed, Cochrane and Embase databases. Randomised, controlled studies that described the Nordic diet and cardiovascular disease were included. A total of 15 articles were included. These are based on four dietary intervention studies conducted in the Nordic countries.

RESULTS All of the dietary intervention studies indicated effects on blood lipids. In one of the studies, a Nordic diet caused a 21 % reduction in LDL cholesterol levels. Three of the studies showed that a Nordic diet reduces blood pressure. Results from two of the studies showed that it also improved glucose and insulin sensitivity, but after adjustment for weight loss, this effect disappeared. Three of the studies showed that a Nordic diet may positively affect inflammation.

INTERPRETATION A diet based on the authorities' dietary recommendation and consisting of Nordic ingredients improves the risk profile in those who are predisposed to developing cardiovascular disease.

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MAIN MESSAGE

A healthy Nordic diet in accordance with the recommendation improves the lipids profile

A healthy Nordic diet has a favourable impact on blood pressure

A healthy Nordic diet may have a favourable impact on inflammation

Cardiovascular diseases are a leading cause of morbidity and mortality, globally as well as in Norway (1, 2). It has been well documented that a Mediterranean diet prevents development of these diseases (3–5). The Mediterranean diet is characterised by a high intake of fruits, legumes, vegetables, olive oil, cereals and nuts, a moderate intake of fish, lean dairy products and red wine and a low intake of red meat (6).

It is questionable, however, whether a single type of regional diet should be recommended world-wide – because of the cost, limited access to relevant ingredients and cultural differences in eating habits (7–9). The kinds of food that we eat have a major impact on the environment, since foods are transported over long distances (10). To take regional differences in terms of food culture as well as agricultural conditions and sustainability into account, a healthy Nordic diet has been proposed as an alternative to the Mediterranean diet (11).

This diet consists of ingredients found in the Nordic region – berries, cabbage, fish and seafood, lean game meat, rapeseed oil and cereals such as oats, rye and barley, all of which are included in the authorities' dietary recommendations (12). This review article describes the effect of a Nordic diet consisting of regional foods on risk factors for cardiovascular disease.

Method

On 8 August 2016 we conducted a search in the PubMed, Cochrane and Embase databases. The search terms «Nordic diet AND health effects» produced a total of 98 hits, reduced to 83 after removal of duplicates (Figure 1). After excluding articles that did not relate to health effects of a Nordic diet a total of 23 remained, whereof 12 reported results from randomised, controlled studies of cardiovascular disease in adults. In addition, we included three additional articles that described health effects of key Nordic ingredients but were not encompassed by the search.

A total of 15 articles are included in this summary. No time limit was defined with regard to publication year, but the searches were restricted to studies of humans and full-text articles (not conference papers). Searches in PubMed included articles in Norwegian, Swedish, Danish and English. No language restrictions were defined for searches in the Cochrane Library and Embase databases.

The 15 articles (13–27) that were included are based on four randomised, controlled dietary intervention studies (Table 1) (13, 15, 18, 19, 28, 29). These studies were conducted in Sweden (NORDIET) on persons with moderately elevated cholesterol levels; in Denmark (New Nordic Diet, NND) on overweight people; and in Finland (SYSDIMET) on moderately overweight people with reduced glucose metabolism. Finally, a joint Nordic intervention study (SYSDIET) had been conducted in Finland, Sweden, Denmark and Iceland on people with metabolic syndrome.

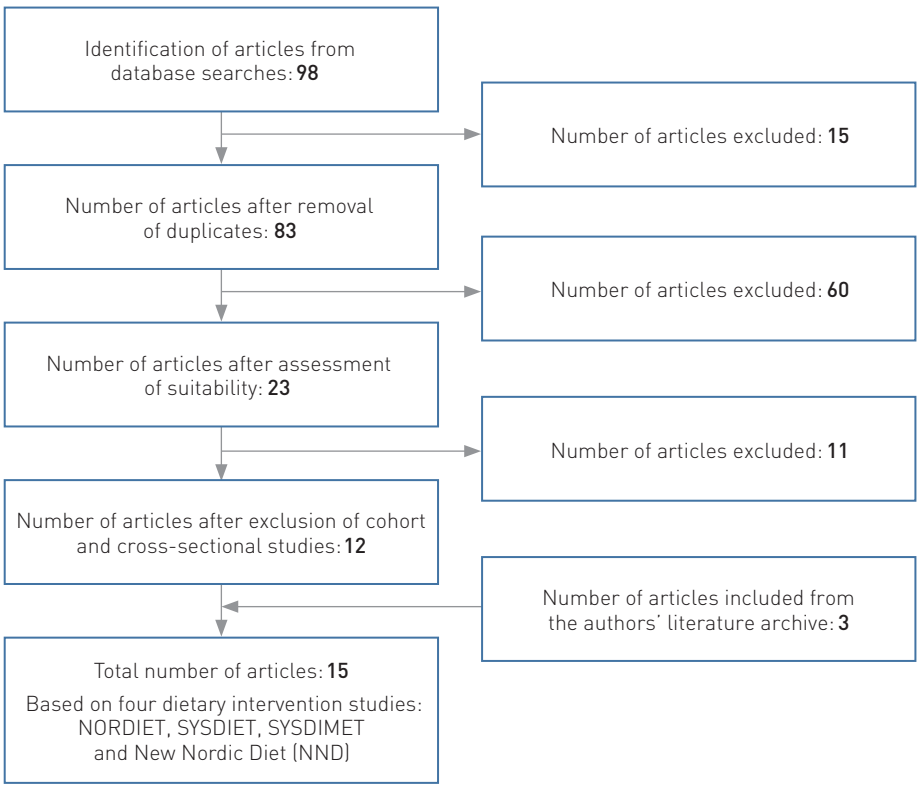

Figure 1 *Procedure for selection of articles from searches in the databases PubMed, Cochrane and Embase with the search terms «Nordic diet AND health effects»*

Altogether 600 persons were randomised and 505 completed the intervention studies, which lasted for 6–26 weeks. The highest rate of attrition was found in the SYSDIET and NND studies, where a total of 34 participants dropped out of each study. The SYSDIET study had its greatest attrition in the control group (n = 26), the NND study had the greatest attrition from the group that ate the Nordic diet (n = 22). The SYSDIMET study had a total attrition of 25 participants, equally divided between the groups. In the NORDIET study, one participant from each group dropped out. The reasons for attrition varied, but the main ones were difficulties in eating the food, lack of motivation and lack of time.

Lipids

All the dietary intervention studies determined that a Nordic diet had an effect on blood lipids.

In the NORDIET study (Table 1), total cholesterol levels were reduced by 0.98 mmol/l and the LDL cholesterol level by 0.83 mmol/l in the group that ate a Nordic diet. In the control group, total cholesterol levels increased by 0.23 mmol/l, whereas the LDL cholesterol level increased by 0.10 mmol/l. The changes were significantly different in the two groups ($p < 0.0001$ and $p < 0.001$ respectively). At baseline, the diet was more or less identical. It was the reduction in serum concentration of the saturated fatty acids C14:0, C15:0 and C18:0 and the increase in the polyunsaturated omega-3 fatty acid 22:6, n-3 that was related to the improvement in the lipid profile (22).

In the SYSDIET study (Table 1) the non-HDL cholesterol level was reduced by 0.22 mmol/l and 0.06 mmol/l among those who ate a Nordic diet and in the control group respectively. The change was significantly different in the two groups ($p = 0.04$) (15).

In the NND study (Table 1), the levels of triglycerides, total cholesterol and VLDL cholesterol were reduced by 0.04 mmol/l, 0.17 mmol/l and 0.02 mmol/l respectively in the group that ate the Nordic diet. In the control group, the levels of triglycerides, total cholesterol and VLDL cholesterol increased by 0.16 mmol/l, 0.08 mmol/l and 0.06 mmol/l respectively. The changes were significantly different in the two groups ($p = 0.004$, $p = 0.010$ and $p = 0.008$ respectively) (18). Weight reductions were found in both groups at the end of the intervention, but the change was greater among those who had eaten a Nordic diet, and it was significantly greater than in the control group ($p < 0.001$). After adjustment for weight change, there was a significant reduction in the triglyceride ($p < 0.046$) and VLDL cholesterol levels ($p = 0.05$) only in the group that had eaten a Nordic diet, when compared to the control group. The weight change was maintained after another 52 weeks (21).

The total cholesterol and LDL cholesterol levels are key risk factors for development of cardiovascular disease (30, 31), and these studies show that a healthy Nordic diet has a favourable effect on the risk profile among persons who are at risk of developing cardiovascular disease. Statin treatment reduces the LDL cholesterol level by 30–60 % (32). A 21 % reduction in the LDL cholesterol level after a change of diet in the NORDIET study (13) is clinically relevant, and the effect is considerable in light of the fact that the diet includes a number of components that give rise to biological effects.

The strong reduction in LDL cholesterol level in the NORDIET study may be caused by the fact that the intake of saturated fat was reduced from 14 per cent of energy to 5 per cent of energy in the group that ate a Nordic diet, in addition to an increased intake of fibre, as recommended by previous studies (31). Such a change in the intake of saturated fat may be difficult to achieve unless the participants are provided with all the food they are intended to consume.

In the SYSDIET study, in which the participants were given advice on replacing food items or reducing the intake of certain products, the change in intake of saturated fats was smaller than in the NORDIET study. In the SYSDIET study, post hoc analyses were made of the participants' diet on the basis of biomarkers in blood linked to intake of oily fish, vegetables, wholegrain cereals and linseed oil. Judging from biomarker levels in the bloodstream, those who maintained the highest degree of compliance achieved a favourable effect on their total cholesterol and LDL cholesterol levels (24).

This corroborates the findings that the better the compliance with the dietary advice, the greater the reduction in risk of cardiovascular disease. In addition, a significant change in the plasma lipidomic profile (all types of lipid metabolites in plasma) was observed between the groups in the SYSDIET study (25). Profiling of all lipids in the blood can more sensitively register metabolic changes and specific lipid metabolites linked to risk of disease (33). In the SYSDIET study, the level of metabolites (plasmalogens) with antioxidant properties increased, and the level of metabolites (ceramides) that are linked to the development of insulin resistance was reduced in the group with a Nordic diet (25). The meaning of these results is uncertain.

In the SYSDIMET study (Table 1), an

Table 1 Overview of the diets in the intervention studies

Study	Group with a healthy Nordic diet	Control group diet	Number of participants	Duration	Inclusion criteria
The NORDIET study (13)	All food was provided to the participants, and all meals with the exception of breakfast were pre-prepared. The nutrients in the menu were based on Nordic Nutrition recommendations. The food items were to be available in stores, and 80 % of the food was to be possible to source from the Nordic region (28). The food was to be eaten ad libitum. *Cereals:* Wholegrain in breakfast cereals, bread, porridge and pasta (rye, barley and oats). *Vegetables, fruits, berries:* Root vegetables, apples, pears, blueberries and lingonberries. *Fats:* vegetable rapeseed/sunflower/linseed oil (38 % fat) without added plant sterols for sandwiches, liquid vegetable rapeseed/sunflower/linseed oil-based margarines for cooking (80 % fat). Rapeseed oil for dressings. *Dairy products:* Lean dairy products and cheese (≤ 17 % fat). *Fish:* Oily fish (salmon, mackerel, herring). *Meat:* Chicken, beef, pork, lamb and reindeer. *Beverages:* Normal alcohol intake, water, tea, coffee, fruit and vegetable juices, non-alcoholic beer.	Encouraged to maintain their usual diet. No food was provided.	88	6 weeks	Healthy, 25–65 years, plasma LDL-C ≥ 3.5 mmol/l; BMI ≥ 20 kg/m^2 and ≤ 31 kg/m^2; and haemoglobin concentration ≥ 120 g/l for women and ≥ 130 g/l for men
The SYSDIET study (15)	The diet was based on the Nordic nutrition recommendations. The participants were advised about what to eat, and certain products were provided. Isocaloric diet. *Cereals:* ≥ 25 % of the total energy was to come from wholegrain products (whereof ≥ 50 % from rye, barley and oats). Wholegrain pasta and rice (≥ 6 g fibre/100 g) ≥ 2–3 meals/week. Bread (≥ 6 g fibre/100 g), ≥ 6 slices/day. *Vegetables, fruits and berries:* ≥ 500 g/day, of which berries ≥ 150–200 g/day, fruit ≥ 175 g/day and vegetables ≥ 175 g/day. *Fats:* Rapeseed oil. Rapeseed and/or sunflower and/or soybean oil-based margarine for sandwiches. *Dairy products:* Lean dairy products ≤ 1 % fat, cheese ≤ 17 % fat, avoid yoghurts and milk products containing sugar. *Fish:* ≥ 3 meals/week, whereof 2 from oily and 1 from white fish. *Meat:* Primarily white meat, chicken and game. *Beverages:* No beverages containing sugar.	The diet was based on data from national nutrition surveys in the Nordic region. The participants were advised about what to eat. Some products were provided. *Cereals:* ≥ 25 % of the energy from refined products, whereof ≥ 90 % from wheat. *Vegetables, fruits and berries:* 200–250 g/day, no blueberries. *Fats:* Butter and other products made from dairy fats. *Dairy products:* No restrictions. *Fish:* ≤ 1 meal/week. *Meat:* No restrictions. *Beverages:* No restrictions.	200	18–24 weeks	30–65 years, BMI 27–38 kg/m^2, fasting plasma glucose ≤ 7.0 mmol/l and 2-hour glucose value < 11.1 mmol/l with an oral glucose test and two other criteria for metabolic syndrome (IDF criteria).

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The New Nordic Diet (NND) study (18)	A diet based on 15 food groups , primarily organically grown and of Nordic origin, based on the national nutrition recommendations and the Nordic nutrition recommendations (29). The participants collected food at no charge from a research store, and a specially prepared cookbook was to be used for preparation of meals. *More calories from plants and fewer from meat:* Legumes, root vegetables, herbs, potatoes, wholegrain cereals, fruit (apples, pears). *More foods from the sea and lakes:* Fish, shellfish, seaweed. *More foods from the forest/grown in the wild:* Berries, nuts, mushrooms, game meat.	The diet was based on ingredients that are characteristic of Danish eating habits as described by national nutrition surveys. The participants collected food at no charge from a research store, and a specially prepared cookbook of traditional Danish dishes was to be used. Refined products of pasta and rice. Vegetables with little fibre and imported fruits (citrus, bananas, melon). Dairy products and cheese, products containing sugar.	181	26 weeks	18–65 years, waist measurement ≥ 80 cm for women and ≥ 94 cm for men. In addition, one or more of the following criteria: Plasma triglyceride concentration ≥ 1.7 mmol/l, HDL-C concentration ≤ 1.03 mmol/l for men, ≤ 1.29 mmol/l for women, hypertension (systolic/diastolic blood pressure > 130/85 mm Hg), weakened fasting glucose.
The SYSDIMET study (19)	The participants were advised about what to eat, and products were provided. **Healthy diet group** *Cereals:* ≥ 20–25 % of the total energy (90 % rye bread), wholegrain pasta (≥ 6 g fibre/100 g), 3.5 dl/week. *Fish:* 3 meals/week of oily fish (100–150 g/serving). *Blueberries:* 3 servings/day (300 g/day in total). **Wholegrain enriched diet group** *Cereals:* ≥ 20–25 % of the total energy (90 % rye bread), wholegrain pasta (≥ 6 g fibre/100g), 3.5 dl/week, wholegrain biscuits (1 serving/day, 8–8.5 g fibre/100 g). *Fish:* No change of previous habits. *Berries:* No change of previous habits.	The participants were advised about what to eat, and products were provided. *Cereals:* Replace regular bread with bread from wheat (3–4 g fibre/100 g), pasta (< 6 g fibre/100 g) Max. 1–2 servings of rye products/day. *Fish:* Max. 1 meal/week. *Berries:* Blueberries were not permitted and max. 3–4 servings of other berries/week (1 dl/serving).	106	12 weeks	40–70 years, lowered fasting glucose 5.6–6.9 mmol/l or lowered glucose tolerance 7.8–11 mmol/l with oral glucose test, plus at least two of the following: BMI 26–39 kg/m^2, waist measurement ≥ 102 cm in men, ≥ 88 cm in women, serum triglyceride >1.7 mmol/l, HDL-C < 1.0 mmol/l in men and < 1.3 mmol/l in women, and blood pressure ≥ 130/≥ 85 mm Hg.

increased intake of fish was associated with an increase in large HDL particles (17). In the NORDIET study, the level of HDL cholesterol was reduced by 0.08 mmol/l in the group with a Nordic diet, while increasing by 0.11 mmol/l in the control group. The effect was significantly different in the two groups ($p = 0.001$) (13). In the SYSDIET and NND studies, the HDL cholesterol level did not change significantly (15, 18).

The impact of HDL cholesterol levels on the risk of cardiovascular disease remains unclear. Although observational studies have shown that a high level of HDL cholesterol is associated with a lower risk of cardiovascular disease (34), the clinical importance of a reduction in HDL cholesterol levels is unknown, since studies of drugs that increase HDL cholesterol levels have not found any reduction in cardiovascular disease (35, 36). Compared to the positive effect of reduced total cholesterol and LDL cholesterol levels, this small reduction in HDL cholesterol levels most likely plays a minor role for the risk of cardiovascular disease.

Blood pressure

In three of the four intervention studies a significant reduction in blood pressure was observed after intake of a Nordic diet. In the SYSDIET study no effect on the systolic or diastolic blood pressure was observed (15), but in a sub-project that included only participants in Denmark, 24-hour diastolic blood pressure was reduced by 3.7 mm Hg and average arterial blood pressure by 3.9 mm Hg in the 37 individuals who ate a Nordic diet. In the control group, there was an increase of 0.8 mm Hg and 0.4 mm Hg in 24-hour diastolic blood pressure and average arterial blood pressure respectively. The changes were significantly different in the two groups ($p = 0.001$ and $p = 0.006$ respectively). There was no effect on systolic blood pressure.

In the NORDIET study, systolic blood pressure was reduced by 6.55 mm Hg in those who ate a Nordic diet, while increasing by 0.6 mm Hg in the control group. The difference was significant ($p < 0.008$), but this effect disappeared after adjustment for weight change in the group with a Nordic diet. In the NND study, systolic and diastolic blood pressure was reduced by 4.48 mm Hg and 3.08 mm Hg respectively. In the control group, systolic and diastolic blood pressure increased by 0.72 mm Hg and 0.11 mm Hg respectively. The changes were significant in the two groups ($p = 0.001$ and $p = 0.009$ respectively) (18). The change in systolic blood pressure in the NND group remained significant after adjustment for weight loss ($p = 0.041$).

There are reasons to assume that diastolic blood pressure may possibly predict mortality for people younger than 50 years (37). The observed reduction in blood pressure in the SYSDIET study could therefore be important; the results correspond to those in studies of the Mediterranean diet (38, 39). Given that the diet in the SYSDIET study was isocaloric and the participants' body weight remained stable, weight loss cannot explain the observed reduction in blood pressure.

Salt intake has been shown to have an effect on blood pressure (31). The changes in blood pressure in the SYSDIET sub-pro-

ject was not associated with changes in salt intake. This indicates that it is the combination of food items in the Nordic diet that helps lower blood pressure.

Glucose metabolism and insulin sensitivity

In two of the four intervention studies, changes were observed in the markers for glucose and insulin sensitivity. In the NORDIET study, the insulin level was reduced by 0.5 mU/l, and insulin sensitivity, measured as HOMA-IR, was reduced by 0.11 in the group that ate the Nordic diet. In the control group, the insulin level increased by 0.90 U/l, and HOMA-IR increased by 0.22. The changes were significantly different in the two groups ($p = 0.01$ and $p = 0.01$ respectively), but the difference disappeared after adjustment for weight change.

In the NND study, the level of fasting glucose was reduced by 0.16 mmol/l and 0.05 mmol/l in the group that ate the Nordic diet and the control group respectively. The changes were significantly different ($p = 0.040$), but disappeared after adjustment for weight change (18). This indicates that the insulin and glucose sensitivity was mainly affected by the weight change, and that dietary changes play a lesser role.

This result is consistent with the absence of effect on glucose and insulin sensitivity in the SYSDIET and SYSDIMET studies, where the participants maintained a stable weight throughout the study period (15, 19). In the NND study, plasma metabolome analyses (measurement of all types of metabolites in plasma) that linked weight changes and improved insulin sensitivity to metabolic processes such as increased ketosis and increased gluconeogenesis were also undertaken (23).

Inflammation

In three of the four intervention studies it was demonstrated that a Nordic diet may have an effect on inflammation markers. In the SYSDIMET study (19), the serum level of E-selectin was significantly reduced with a diet based on oily fish, blueberries and wholegrain cereals ($p = 0.04$). There was also a significant reduction in the level of high-sensitivity CRP (hsCRP) of 0.3 mg/l within the group that ate wholegrain cereals ($p = 0.02$). Elevated levels of hsCRP increase the risk of cardiovascular disease (40).

Among those participants in the SYSDIMET study that did not use statins there was an association between increased intake of fibre and marine omega-3 fatty acids and a reduced level of E-selectin. There was a significant correlation between a higher intake of bread, especially rye bread, and a lower level of hsCRP. This may indicate that marine omega-3 fatty acids and fibre could be key factors in the Nordic diet when it comes to reducing inflammation.

In the SYSDIET study, an increase in the inflammation marker IL-1Ra was observed in the group with a control diet when compared to the intervention group ($p < 0.0001$). However, there was no increase in any other inflammation markers (15). IL-1Ra is considered a sensitive marker for inflammation in persons with overweight and metabolic syndrome. It has been shown to predict onset of type-2 diabetes and progression from metabolic syndrome to type-2 diabetes (41–44). In the SYSDIET study, there was an association between intake of saturated fats and an elevated IL-1Ra level (15).

To obtain a better biological understanding of the function of adipose tissue and the impact of diet on inflammation, gene expression in adipose tissue was examined in the SYSDIET study (27). The results showed that a Nordic diet leads to a reduced expression of genes that code for inflammatory markers. These results concur with the results from a study on the Mediterranean diet, showing that Mediterranean foods may modulate the expression of genes that code for proatherogenic factors in adipose tissue (45). In the SYSDIET study, the expression of inflammatory genes in peripheral leukocytes after a glucose tolerance test was reduced by a Nordic diet, but the clinical importance of this finding for the development of metabolic syndrome remains uncertain (26).

In the NORDIET study, there was a significant difference in the changes in the levels of cathepsin S between the groups ($p = 0.03$) (14). Cathepsin S is a proteolytic enzyme found in macrophages and smooth muscular cells in atheromatous lesions in arteries. An elevated level of cathepsin S in serum is linked to cardiovascular disease, diabetes and inflammation, and the level is elevated in adipose tissue and serum in overweight individuals (46, 47). The reduction in cathepsin S was correlated with weight loss and a reduction in total cholesterol and LDL cholesterol levels, which may indicate that the level of cathepsin S is not directly influenced by the diet.

Discussion

A Nordic diet based on the authorities' dietary advice and consisting of Nordic foods affects a number of key risk factors for cardiovascular disease. The effect in terms of reduction in cholesterol level and blood pressure is equal to the effect observed with a Mediterranean and other equivalent diets (48).

In Norway and several other Western countries, average blood pressure has declined since the 1980s (49, 50), even in those who use no antihypertensive drugs and in spite of weight gain. The reason is unknown, but a reduced intake of salt and an increased intake of fruits and vegetables, which contain a lot of potassium, may be of importance – and line with the findings in this review article. In addition, some of the studies showed that a healthy Nordic diet reduces body weight, which in turn affects some of the risk factors, including insulin and glucose sensitivity. Whether the effect of a Nordic diet is just as beneficial as that of a Mediterranean diet is unknown, since no randomised, controlled dietary studies that directly compare their respective effects are available.

In a dietary intervention it is a challenge to decide what the control group should eat. A weakness found in three of the studies is that the control groups were provided with guidelines that may pull their diet in an «unhealthy» direction – a maximum of one fish-based meal per week, use of butter and dairy fats, vegetables with little fibre content, products containing sugar, no intake of blueberries and restrictions on the intake of other berries (Table 1). This tends to reinforce the observed intervention effect. However, it highlights the impact of a Nordic diet based on the authorities' dietary advice versus adhering to a «habitual» diet.

Cardiovascular diseases give rise to increased morbidity and mortality, and drugs for prevention and treatment of these diseases are among the most sold in Norway (51). The authorities' dietary advice, provided with a view to improving public health (12), implies consumption of foodstuffs equivalent to those recommended in the studies that are summarised in this article.

All the studies included in this review article describe risk markers, not hard endpoints. We cannot therefore draw conclusions regarding the effect of a Nordic diet on the incidence of disease or possible prognoses. On the other hand, a Mediterranean diet has been shown to result in a reduced prevalence of cardiovascular disease in persons who are at risk of developing disease (3). It would thus be of considerable interest to undertake an equivalent study in the Nordic countries with hard endpoints to be able to document whether a Nordic diet based on Nordic foodstuffs and the authorities' dietary advice has an impact in persons with risk factors (early secondary prevention) and the population as a whole.

The gain in the form of better public health is greater in the case of a modest dietary change in a favourable direction in the population as a whole (primary prevention) than in a targeted intervention among patients and people who are at risk. Among the studies described in this article, only the

SYSDIET study investigated the effect of communication of the Nordic nutrition recommendations. This communication was undertaken by clinical nutritionists who provided advice on the kinds of food items that the participants should choose, in addition to provision of certain key food items.

A recent Norwegian study in which a few commercially available food items were replaced by equivalent products that had a better composition of fatty acids (a higher proportion of polyunsaturated fats) for eight weeks found clinically relevant changes in the total cholesterol and LDL cholesterol levels resulting from minor changes to the daily diet (52). The change in LDL cholesterol level was identical to the change found in the Improve-it study, which tested the effect of ezemitibe as add-on therapy to statin treatment (53). This showed that dietary change may be as effective as add-on medication for those who receive statin treatment. It is therefore crucial for doctors and clinical nutritionists jointly to communicate this knowledge and motivate patients to eat in accordance with the current dietary guidelines.

By maintaining a Nordic diet with Nordic ingredients that are easily available and well known, food can be good medicine.

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The author has completed the ICMJE form and declares the following conflicts of interest: She has received contributions from Mills, TINE and Olympic Seafood.

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