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Diabetes preventive components in the Mediterranean diet

Summary The so-called Mediterranean diet is claimed to be preventive with respect to diet-related degenerative diseases. It is suggested that the preventive effect especially with respect to diabetes might be the low glycemic index of this kind of diet. However, nutrients with a high GI are more frequently consumed in the Mediterranean diet than in other European countries. The major difference seems to be the higher amount of fiber and a higher intake of unsaturated fat together with a higher intake of fruits and vegetables. Based on recent studies from the nurses health and physicians health study, a diet which is similar to the Mediterranean diet, physical exercise and a BMI < 25 protects from the development of diabetes type 2.

Key words diabetes – Mediterranean diet – glycemic index

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Introduction

There are two major aspects which might explain the dramatic increase of diabetes: life-style changes and genetic predisposition. Based on these findings diabetes is a classical nutrient-gene-interaction disease. A major lifestyle-related reason for diabetes is decreased physical exercise and the increase of food with a high glycemic index. On the metabolic side insulin resistance favors the development of diabetes type II. Regarding insulin resistance two main mechanisms leading to diabetes have been hypothesized: one mediated by increase of insulin resistance and the other ß-cell insufficiency as a result of the increased demand for insulin. Based on a couple of experimental, epidemiological and clinical studies there are now several lines of evidence that diets leading to a high insulin response promote the development of diabetes. A high insulin response is a consequence of absorption of carbohydrates with a high gylcemic index (a relative measure of the incremental glucose response per g carbohydrate). In prospective epidemiological studies both the glycemic index and the glycemic load (the glycemic index multiplied by the amount of carbohydrate) of the overall diet have been associated with a greater risk of type II diabetes. To lower the insulin secretion and to improve the glycemic control carbohydrates with a low glycemic index or load are recommended. Dietary changes which replace carbohydrates with a high glycemic index (e. g. white flour, baked potatoes) by products with a low GI/GL (minimally refined cereal products, whole grain products) have also been associated with a lower risk of cardiovascular disease and diabetes. A diet with a low GI/GL is hypothesized to be the reason for the lower incidence of diabetes and coronary heart disease in the Mediterranean area.

The diet in the Mediterranean area is composed of

- Vegetables (mean 250 g/capita/day)
- Olive oil containing vitamin E and monounsaturated fatty acids
- Carbohydrates (pasta, bread)
- Fish more than meat and
- Red wine.

The question arises whether and how a "Mediterranean" diet may contribute to a risk reduction for diabetes in "non-Mediterranean" countries? According to this, lifestyle factors which are a component of either tradition or the specific climate in the Mediterranean area and may have a more or less important influence on diabetes and coronary heart disease must be excluded. Di-

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etary carbohydrates and the food matrix, either native or processed, play major roles with respect to the interaction of GI/GL.

The role of different foods on glucose and insulin response

The amount, type and rate of digestion of dietary carbohydrate are the primary determinants of postprandial glucose and insulin responses. The food matrix and composition and the process of food preparation has a major influence on glucose and insulin response. Table 1 summarizes the different food factors influencing glycemic response.

There are important differences between the GI of different sugars. The GI of a sugar is determined primarily by its content of readily available glucose residues. Thus maltose (disaccharide with two glucose units) has a GI close to 100 whereas sucrose (glucose plus fructose) has a GI of only 87. The GI of fructose (using bread as a standard) is only 32, which is explained by the partial conversion of fructose into glucose at high intakes of a standard test meal. In addition to the quantity and digestibility of starches and the quantities and sources of sugars in a meal, many factors influence the gylcemic responses to foods. The ratio of amylase to amylopectin in the starch is important in determining the GI: amylopectin is more rapidly degraded than amylase. Large amounts of protein and fat present in a diet with high glucose affect postprandial glycemic and insulin response: protein increases insulin and decreases glucose and fat is generally considered to reduce glucose and insulin because of reduced upper gastrointestinal motility. In addition fat promotes the secretion of GIP (gastric inhibitory polypeptide) which increases insulin secretion. The latter is influenced by a couple of further factors summarized in Table 2

Taken together the postprandial glucose pattern is based on a couple of aspects starting with the composition of the meal, the individual metabolic response and other factors which can be hardly calculated. As a consequence the dietary GI is directly relevant in metabolic studies in which the total carbohydrate content is held constant; in free-living populations, the amount of carbohydrate and its composition varies among individuals.

Table 1 Food factors that influence glycemic response

Nature of the monosaccharide components
Glucose
Fructose
Galactose
Nature of the starch
Amylose
Amylopectin
Starch-nutrient interaction
Resistant starch
Cooking or food processing
Degree of gelatinization of starch
Particle size
Food form
Cellular structure
Food components
Fat and protein
Dietary fiber
Antinutrients
Organic acids

The "preventive" components of the Mediterranean diet

The traditional Mediterranean diet has, according to Trichopoulou [1] eight major components:

1. High monounsaturated:saturated fat ratio
2. Moderate alcohol consumption
3. High consumption of legumes
4. High consumption of cereals (e. g. bread)
5. High consumption of fruits
6. High consumption of vegetables
7. Low consumption of meat and meat products
8. Moderate consumption of milk and dairy products

Except the high consumption of cereals, especially bread, this is a mixed and healthy diet (if fish consumption is considered). Table 3 compares the dietary pattern in European countries and in Northern and Southern Italy.

Major components of the Mediterranean diet especially in Southern Italy (I/S) are carbohydrates. Based on the above mentioned aspects a diet high in carbohydrates (CH; especially refined CH as in white bread which is a major component in the Mediterranean diet) contributes to a higher disease risk in epidemiological studies. The Italian population shows the highest consumption of CH from refined cereals among affluent

Table 2 Factors influencing insulin secretion

Stimulation of insulin secretion
Increase in blood glucose concentration
Increase in blood levels of certain amino acids
Glucose in intestine (mediated via GIP)
Other gut hormones (gastrin, secretin)
Glucagon
Parasympathic stimulation
Inhibition of insulin release
Adrenaline
Sympathetic stimulation
Somatostatin

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Table 3 Summary of the dietary composition in different European countries [2]

Food group (g/day)	NL	B	G	F	I/N	I/S
Cereals	263	303	289	351	333	486
Fruits & vegetables	459	573	528	473	298	426
Meat & fish	88	150	154	190	78	62
Milk & dairy products	525	353	282	344	297	87
Fats & oils	65	29	71	64	49	51
Sugar	65	29	31	42	54	15
Sweets	21	25	60	22	4	1

NL The Netherlands; *B* Belgium; *G* Germany; *F* France; *I/N* Northern Italy; *I/S* Southern Italy

Table 4 Fiber content (g/day) of various European diets

Food group	NL	B	G	F	I/N	I/S
Potatoes	2.8	5.1	3.6	2.8	1.7	0.5
Roots & tubers	0.9	1.2	0.7	2.1	0.4	0.2
Leafy vegetables	1.6	1.5	1.3	1.2	1.3	2.4
Fruit vegetables	1.1	0.9	0.7	1.0	0.9	2.7
Fruits	3.2	2.8	3.7	2.9	1.7	3.9
Cereals	10.4	10.1	11.4	10.5	12.2	14.7
Total	20.1	21.6	21.5	20.5	18.2	24.4

NL The Netherlands; *B* Belgium; *G* Germany; *F* France; *I/N* Northern Italy; *I/S* Southern Italy

countries [3] that is, up to more than 300 g/day in the highest quintile of consumption. The main sources are white bread and its substitutes (crackers, grissini, Melba toasts) and various types of pasta or rice dishes. Alltogether this accounts for almost 40 % of the total CH intake in Italy [4]. Studies on non-diabetic subjects generally show beneficial effects of a high carbohydrate diet on insulin sensitivity (improvement between 26 and 83 %), while those in diabetic subjects show the opposite [5].

A diet rich in CH (with high GI) induces increased insulin secretion in order to maintain glucose homoeostasis. In young and healthy subjects a sufficient secretion of insulin to maintain glucose homoeostasis might not be critical as documented in the above mentioned study. However, in cases of insulin resistance this may lead to a progressive loss of adaptation of the secretory potency of the pancreas, leading at least to diabetes type II. The efficacy of a Mediterranean diet was documented in a recent study [6]. A high GI and GL were not associated with a higher incidence of myocardial infarction in 433 non-diabetic subjects. However, in a subgroup of elderly (> 60 y) and overweight subjects (BMI > 25), most likely to have insulin resistance a positive association between GI and acute myocardial infarction was found. This is in good agreement with the nurses health study which found a doubled risk of CHD with a high glycemic load in women with a BMI > 23, but not in those with lower BMI [7].

This is important with respect to the general recommendation that eating a Mediterranean diet would be healthy in any case. A high carbohydrate content of the diet, especially with a high GI/GL might not be ideal for either diabetic patients or those with pre-diabetes and insulin resistance. However, if the dietary carbohydrates are rich in fibers this might contribute to a lower risk for diabetes and CHD (Table 4).

As expected from the high intake of total carbohydrates, the total amount of dietary fiber exceeds the amount in all food groups in Southern Italy compared to the other European countries, except potatoes.

Soluble fiber-rich foods have a low GI, in general less than 50 % compared with starch-rich foods. It is assumed that their low glycemic potential is due to their high viscosity, which prolongs nutrient digestion and absorption in the small intestine [8]. Indeed, Riccardi and coworkers [9] showed that a diet based on natural fiber-rich food reduced the glycemic response by 40 % compared with a control diet enriched with either guar or hydrolyzed guar (Riccardi). The fiber rich and guar-enriched diet slows gastric emptying (50 %) but only the natural fiber-rich diet was effective in reducing postprandial plasma glucose concentration. Based on these data gastric emptying might not be the major reason for the lower GI. Fiber in low or unprocessed food surround the carbohydrate granules to form a physical barrier that protects the carbohydrate from absorption. Consequently the lower accessibility of carbohydrates from unrefined food or food were the fibers were disrupted following processing (e. g. heating with very high temperature) to the digestive and absorptive process results in a lower GI. Indeed, the metabolic effect of a food consumed under different physical forms (e. g. whole, milled or mashed) shows marked differences in the glycemic response [10–12]. So far a more or less natural diet with high fiber content contributes to a low glycemic index. Accordingly, scientists, media and a few health organizations which claim to reduce CH intake should discriminate between fiber rich and fiber poor CH.

Beside the high intake of carbohydrates, including refined CH, the Mediterranean diet contains a high amount of monounsaturated fatty acids and due to a moderate intake of meat and meat products a high ratio of MUF/SFA (Table 5).

The data of the Mediterranean group for the study of diabetes give evidence that a high intake of animal fat contributes to the development of diabetes in Mediterranean countries [13].

Perez-Jimenez and coworkers [14] showed that the isocaloric substitution of CH or MUFA in an enriched Mediterranean diet for SFA in young healthy nor-

Table 5 Dietary fat in the diet of European countries [11]

Fat source (g/day)	NL	B	G	F	I/N	I/S
Butter	8	37	36	52	11	1
Margarine	42	25	25	2	–	–
Vegetable oil	–	8	7	10	26	49*
Other fats	3	4	3	–	9	1
Total dietary lipids	102	129	122	109	91	73
% energy from fat	39	43	43	37	34	28

NL The Netherlands; *B* Belgium; *G* Germany; *F* France; *I/N* Northern Italy; *I/S* Southern Italy

molipemic population improves in vivo insulin sensitivity as documented by the insulin suppression test. They also described an increase in in-vitro glucose uptake by monocytes obtained during a Mediterranean diet and the CH diet. These findings were positively correlated with in vivo glucose disposal and consequently this should contribute to lower insulin consumption. Based on the fat intake in southern Italy, this results in a very high M/S ratio (3.87) compared to Germany (0.77) or France (0.45). However, the P/S ratio does not differ between European countries (mean 0.45) and Southern Italy (0.53) [11]. The role of dietary fat in the risk of type 2 diabetes is not clarified. In a 6-year follow-up in a cohort of 42,759 men without diabetes or CHD a combination of a high glycemic load together with a low cereal fiber intake increased risk for NIDDM [15]. There was no association between major types of fat and risk of type 2 diabetes. However, an extension of the analysis of data to 12 years of follow-up showed that intake of total and saturated fat was associated with a higher risk for type 2 diabetes [16]. After adjustment for BMI, however, this association disappeared. Only intake of linoleic acid was inversely associated with type 2 diabetes in men < 65 years and with a BMI < 25. Frequent consumption with processed meat was associated with a higher risk for diabetes type 2.

Conclusion

The data derived from the EURATOM study [2] represent the classical Mediterranean diet which together with a "classical" Mediterranean lifestyle might contribute to a lower risk for CHD and diabetes in the Italian population. Even dietary habits have changed in the past 20 years and new epidemiological data recommend a lower intake of carbohydrates, a mixed diet with preference on fruit, vegetables and carbohydrates with low GI/GL and high fiber content, a total fat intake between 30–35 % high in MUFA and w3-FA and low in SFA seems to be preventative and healthy dietary components of a Mediterranean lifestyle. The total amount of carbohydrates even with a low GI might influence the development of diabetes especially in cases of insulin resistance and obesity. Data from the Nurses Health study and from a recent evaluation in Spain [17] show a relationship between a lower intake of carbohydrates and risk for CHD and diabetes. This has to be proven in further studies including the effect of MUFA, antioxidants and at least the "protective" effects of "Mediterranean" wine-derived polyphenols.

References

1. Trichopoulou A, Lagiou P, Kuper H, Trichopoulos D (2000) Cancer and mediterranean dietary conditions. Cancer Epidemiol Biomarkers Prev 9:869–873
2. Cresta M, Ledermann S, Garnier A (1969) Etude de consommations alimentaires des populations de onze regions de la communauté européenne en vue de la determination des niveaux de contamination radioactive. Rapport établi au centre d'étude nucléaire de Fontenay-aux-Roses, France. EURATOM
3. WCRF/AICR (1997) Food nutrition and the prevention of cancer. American Institute for the Prevention of Cancer, Washington DC
4. Favero A, Salvini S, Russo A (1997) Sources of macro- and micronutrients in Italian women. Eur J Cancer Prev 6:277–287
5. Wolever TMS (2000) Dietary carbohydrates and insulin action in humans. Br J Nutr 83:S97–S102
6. Tavani A, Bosetti C, Negri E, Augustin LS, Jenkins DJA, La Vecchia C (2003) Carbohydrates, dietary glycaemic load and glycaemic index, and risk of acute myocardial infarction. Heart 89: 722–726
7. Liu S, Willett WC, Stampfer MJ (2000) A prospective study of dietary glycaemic load, carbohydrate intake and risk of coronary heart disease in US women. Am J Clin Nutr 71:1455–1461
8. Wursch P, Pi-Sunyer FX (1997) The role of viscous soluble fibre in the metabolic control in diabetes. Diabetes Care 20: 1774–1780
9. Riccardi G, Clemente G, Giacco R (2003) Glycemic index of local foods and diets: the Mediterranean experience. Nutr Rev 61:S56–S60
10. O'Dea K, Nestel R, Autonoff L (1980) Physical factors influencing postprandial glucose and insulin responses to starch. Am J Clin Nutr 33:760–765
11. Liljeberg H, Granfeldt Y, Bjorck I (1992) Metabolic responses to starch in bread containing intact kernels versus milled flour. Eur J Clin Nutr 46:561–575
12. Golay A, Coulston AM, Hollenbeck CB (1986) Comparison of metabolic effect of white beans processed into different physical forms. Diabetes care 9:260–266
13. Thanopoulou A, Karamanos B, Angelico F, et al. (2003) Dietary fat intake as risk factor for the development of diabetes. Diabetes Care 26:302–307
14. Perez-Jimenez F, Lopez-Miranda J, Pinillos MD, Gomez P (2001) A mediterranean and a high-carbohydrate diet improve glucose metabolism in healthy young adults. Diabetologica 44:2038–2043

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15. Salmeron J, Ascherio A, Rimm EB (1997) Dietary fibre, glycemic load, and risk of NIDDM in men. Diabetes Care 20:545–550

16. Van Dam RM, Stampfer MJ, Willet WC (2002) Dietary fat and meat intake in relation to risk of type 2 diabetes in men. Diabetes Care 25:417–424

17. Moreno LA, Sarria A, Popkin BM (2002) The nutrition transition in Spain: a European Mediterranean country. Eur J Clin Nutr 56:992–1003