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FISH CONSUMPTION AND THE RISK OF TYPE 2 DIABETES

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Abstract

It is currently estimated that 285 million people suffer from diabetes in the world and by the year 2025 will be double. Diabetes mellitus appears to confer an excess risk of cardiovascular disease and premature death. Among the lifestyle factors that might influence the development of diabetes, dietary factor is one of the most important. In recent years a number of studies have remarked the nutritional benefits of fish consumption like proteins, vitamins and especially omega-3 polyunsaturated fatty acids which may protect against coronary heart disease, mortality, stroke, type 2 diabetes. Fish must be an important part of a balanced diet but the presence of environmental contaminants found in fish and the cooking method must be essential aspects to balance benefits and risks of a regular consumption. Many studies have been reported a positive effect of diets high in monounsaturated and polyunsaturated fatty acids on insulin sensitivity and glucose control. Is well known that the risk of type 2 diabetes increase with the duration and the degree of obesity.

***key words**: monounsaturated fatty acids, polyunsaturated fatty acids, fish contaminants, glucose control*

The major classes of fatty acids

There are four major families: first Saturated fats among these are like fatty acids: Palmitic acid and Stearic acid. Their source is for palmitic acid animal and vegetable fats and for stearic acid butter, lard, palm oil, palm kennel oil, coconut oil [9].

Another family is that of omega-3 fatty acids with Alfalinolenic acid found in marine and land plants, Eicosapentaenoic acid, found in marine oils and fish Docosahexaenoic acid found in marine oil and fish [10].

The family of omega 6 fatty acids with Linoleic acid found in vegetable oils and Arachidonic acid found in poultry meats and the family of omega-9 fatty acids with Oleic acid found in olive oil, vegetable oils, animal fats.

Fish intake, contaminants and human health

Mozaffarian D and colab [6] searched MEDLINE governmental reports to evaluate intake of fish or fish oil and cardiovascular risk, effects of metylmercury and fish oil on early neurodevelopment risks of metylmercury

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for cardiovascular and neurologic outcomes in adults and risks of dioxins and polychlorinated biphenyls in fish. They found that for major health adults the benefits of fish intake exceed the potential risks. For women of childbearing age is recommended a modest fish intake to outweigh risks.

Hamilton MC and col [10] analyzed lipid composition and contaminants in farmed and wild salmon and concluded that farmed salmon had greater levels of total lipids (average 16,6%). Salmon, especially farmed salmon are a good source of healthy n-3 fatty acids but they also contains high concentrations of organ chlorine compounds like dioxins, chlorinated pesticides and polychlorinated biphenyls [10].

The consumption of fish and shrimp containing omega -3 fatty acids can result in protective health effects including a reduced risk of cardiovascular disease, stroke and diabetes but the presence of mercury in the muscle of fish and shellfish may decrease these protective effects [11].

Salmon, trout and shrimp are species with high quantity of omega -3 fatty acids. In species like tuna, shark, halibut, swordfish and sea bass has in the high quantity both omega-3 fatty acids and mercury [11].

Effects of different cooking procedures on lipid quality and cholesterol oxidation of salmon fish

Al Saghir and col. found no change in the n-3 fatty acids content and in the polyunsaturated /saturated ratio of the cooked salmon fillets. Moderate pan frying (6 min total) and steaming (12 min) of salmon did not accelerated lipid oxidation but significantly increased the content of the sum of cholesterol oxidation products [12]. Due to the longer heat exposure the highest increase in the products of cholesterol oxidation was found through steaming. Between heat treatment with or without oil no significant difference was observed [12].

Heating in the presence of air produces oxidative and thermal degradations in the unsaturated acyl groups of tryacylgycerols and other unsaturated compounds present in the oils and fats [13]. These changes lead to the formation of many oxidized and polymerized compounds.

Echarte M and col. used three different culinary techniques pan-frying with olive oil, with soya oil and roasting [14]. Roasting did not modify the fat content from that of row samples Frying increased the fat content 2 fold there were no differences between samples fried with different oils [14].

Only in the lean fish (cod–Gadus morhua) fat content and total energetic value increase after the frying process [15]. In fatty fish (farmed salmon - Salmo salar) there are not relevant changes. Extra virgin olive oil led to a higher fat absorbtion rate than sunflower oil in both fish. The type of oil has more influence in the nutritional fish quality for the lean fish compared to that of the fatty fish [15].

Fish intake and the risk of type 2 diabetes mellitus

Much controversy exists about the relations between the amount and types of dietary fat and the risk of diabetes [16]. The findings of HuFB and col. from the Department of Nutrition Harvard School of Public Health, Boston Massachusetts USA indicate that a higher intake of polyunsaturated fat and possible long chain n-3 fatty acids could prevent type 2 diabetes. We must avoid overweight and obesity and in dietary practice is recommended to consume

instead of trans fatty acids non hydrogenated polyunsaturated fat [16].

The data from a study on dietary fat intake and risk of type 2 diabetes in women, published in 2001 by Salmeron J and col. [17] concluded that total fat and saturated and monounsaturated fatty acids intakes are not associated with the risk of type 2 diabetes in woman, but polyunsaturated fatty acids reduce the risk and trans fatty acids increase the risk. The authors [17] estimated that replacing 2% of energy from trans fatty acids isoenergetically with polyunsaturated fat would lead to a 40% lower risk of type 2 diabetes.

The epidemiologically studies on long chain omega 3 fatty acids are controversial. Some are associated with a better glucose tolerance [23, 24].

The quality of dietary fat influences in humans insulin sensitivity, monounsaturated and omega 6 polyunsaturated fats improve insulinsensitivity and saturated fat worsens it [18].

Modifying the phospholipids composition of cell membranes may act dietary fatty acids and the consequence will be the alteration of function of the insulinreceptor [18].

The Finish Diabetes Prevention Study show that the incidence of type 2 diabetes was reduced by a reduction of saturated fat intake. Long chain omega-3 fatty acids in humans have no effect on insulin sensitivity [18, 20], also the risk of type 2 diabetes may be influenced by saturated fat and decreased by unsaturated fat [18, 19].

Manas Kaushik and colab examined and published in 2009 a three prospective cohorts of women The Nurses Health Study, (The Nurses Health Study 2 and The Health Professionals Follow –up Study and man in USA and examined the association between dietary long chain omega-3) fatty acids and incidence of type 2 diabetes [21].

The authors concluded that is not evidence that higher consumption of long-chain omega-3(n-3) fatty acids and fish will reduce the risk of type 2 diabetes but due to beneficial effects of them on cardiovascular disease risk factors is necessary that further investigations to be made [21].

For the prevention of type 2 diabetes the diet, life style factors are very important. The risk of type 2 diabetes is increased (data from these studies) by a diet low in omega 6 polyunsaturated fatty acids and high in trans unsaturated fatty acids and the role of omega-3 fats remain unclear [21]. The source of long chain omega-3 fat is seafood, it alters the expression of peroxisome proliferators activator receptor genes which are involved in the production of inflammatory cytokines which are associated with type 2 diabetes [22].

These findings suggest that omega-3 fatty acids could lower the risk of type 2 diabetes mellitus.

The epidemiologic studies on long chain omega-3 fatty acids are controversial. Some are associated with a better glucose tolerance [23, 24] or with a worse one [25, 26].

Some studies suggested that environmental contaminants such as dioxins, from fish might raise the risk of type 2 diabetes [27].

Gllingham LG and col. provide a critical assessment of the current evidence about efficacy of dietary monounsaturated fatty acids for reduction of risk factor defining metabolic syndrome [28].

Consumption of monounsaturated fatty acids promotes healthy blood lipids, improve insulin sensitivity and regulates glucose levels,

ameliorate risk of obesity, influence body composition and have cardio protective role. In the future will be the debate on the optimal fatty acid composition [28].

Yang ZH and col. observed in mice that dietary monounsaturated fatty acids improved insulin resistance and alleviated metabolic syndrome risk factors by reducing blood glucose and lipids [29]. Their data suggest that marine monounsaturated fatty acids improved glucose/lipid homeostasis and hindered the development of metabolic syndrome in obese mice [29, 8].

A diet rich in omega-3 fatty acids both in animals and humans induces insulin release by beta cells, optimizes insulin action at peripheral levels [30]. A protective influence of omega-3 fatty acids has been documented in Alaska Natives [31] a population with a rising prevalence of glucose intolerance [32]. The same is in the elderly [33] who are at a greater incidence of diabetes.

A Nkondjock and col. [34] using on line data base examines whether there is a relation between fish-seafood consumption, omega -3 fatty acids intake and the prevalence of type 2 diabetes.

No significant difference was noted in the prevalence of type 2 diabetes between the study countries with low prevalence of obesity regardless of their total fish seafood consumption [34]. In the presence of greater prevalence of obesity there was significantly reduced type 2 diabetes when the consumption of fish-seafood was great [34].

Katie A Meyer and col. [35] examined the relation between intake of total dietary fat and dietary fat subtypes at baseline and the development of type 2 diabetes over 11 years of follow up in the Iowa Womens Health Study. They found an inverse correlation between incidence of type 2 diabetes and vegetable fat and substitutions polyunsaturated fatty acids for saturated fatty acids and cholesterol [35].

Feskens EJ and col. [36] on a cross check dietary history method on 175 men and women aged 64-87 years who were normoglycemic and free of clinical diabetes on a period 1972-1975. Their results suggest that in an elderly population the habitual consumption of a small amount of fish may protect against the development of impaired glucose tolerance and diabetes mellitus compared with non fish eaters [36].

Yutaka Kiyohara and col. [37] investigated the impact of dietary factors on the development of glucose intolerance (diabetes and impaired glucose tolerance). They surveyed 1,075 subjects over a period of seven years. Their results suggested that a high intake of alcohol and a decreased of polyunsaturated and an increase of saturated fatty acids in diet will increase the risk of glucose intolerance [37].

Conclusions

For the primary prevention of diabetes is important to restrict the westernization of dietary habits and to decrease the obesity and the sedentary life [37].

The prevention of atherosclerosis should begin in childhood thru modification of lifestyle and risk factors. The fish intake can improve glucose metabolism but exist potential adverse effects of environmental contaminants in fish. There are also limitations of the studies like assessment of dietary intake, lack of information about potential toxins from fish or sometimes lack of dietary intake data by cooking method in some dietary studies.

Increasing cereal fiber intake and reducing intake of fat and saturated fat can lower the incidence of type 2 diabetes [37]. A high intake of omega-3 fatty acids found in fish and seafood may induce insulin release by beta cells and may optimize insulin action at the peripheral levels. The diets with high concentration of monounsaturated and polyunsaturated fatty acids have benefic effects on glucose control and insulin sensitivity [5,7] comparative with diets with high concentration in carbohydrates. Obesity remains a major risk factor of type 2 diabetes.

REFERENCES

1. ***IDF Diabetes Atlas, 4th ed.*** International Diabetes Federation 2009.

2. ***World Health Organisation***, DietReport of a Joint WHO/FAO Expert Consultation Technical report N0916 Geneva, WHO, 2003.

3. **Marshall JA, Hamman RF, Baxter J.** High fat, low carbohydrate diet and the etiology of non-insulin-dependent diabetes mellitus the Sun Luis valley diabetes study *Am.J. Epidemiol* 134-590-603,1991.

4. **Domingo JL.** Omega-3 fatty acids and the benefits of fish consumption: is all that glitters gold? *Environ Int* Oct:33(7); 993-8, 2007.

5. **Parillo M Rivellese AA Ciardullo AV et al.** A high monounsaturated fat/low carbohydrate diet improves peripheral insulin sensitivity in non insulin-dependent diabetic patients. *Metabolism* 41, 1373-8, 1992.

6. **Mozaffarian, Rimm EB.** Fish intake, contaminants, and human health: evaluating the risks and benefits. *Jama* Oct18; 296(15); 1885-99, 2006.

7. **Garg A, Grundy SM, Unger RH.** Comparison of effects of high and low carbohydrate diets on plasma lipoproteins and insulin sensitivity in patients with mild NIDDM. *Diabetes* 41, 1278-85, 1992.

8. **Tuomiletho J, Lindstrom J, Erikson J et al.** Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med* 344, 1343-50, 2001.

9. **Harris WS.** Omega-3 fatty acids and cardiovascular disease a case for omega-3 index as a new factor *Pharmacol Res* 55: 217-223, 2007.

10. **Hamilton MC, Hites RA, Schwager SJ, Foran JA, Knuth BA, Carpenter DO**. Lipid composition and contaminants in farmed and wild salmon. *Environ Sci Technol* Nov 15, 39(22); 8622-9, 2005.

11. **Smith KL, Guentzel JL.** Mercury concentrations and omega-3 fatty acids in fish and shrimp. Preferential consumption for maximum health benefits. *Mar Pollut Bull* Sep; 60(9); 1615-8, 2010.

12. **Al Saghir S, Thurner K, Wagner KH, Frisch G, Luf W, Razzazi-Fazeli E, Elmadfa I**. Effects of different cooking procedures on lipid quality and cholesterol oxidation of farmed salmon fish(Salmo salar). *J Agric. Food Chem.* Aug 11; 52(16); 5290-6, 2004.

13. **Sanchez-Muniz FJ.** Oils and fats: changes due to culinary and industrial processes. *Int J Vitam Nutr Res* Jul; 76(4): 230-7, 2006.

14. **Echarte M, Zulet MA, Astiasaran.** Oxidation process affecting fatty acids and cholesterol in fried and roasted salmon. *J Agric Food Chem* Nov; 49(11): 5662-7, 2001.

15. **Ansorena D, Guembe A, Mendizabal T, Astiasaran.** I Effect of fish and oil nature on frying process and nutritional product quality. *J Food Sci* Mar; 75(2); H62-7, 2010.

16. **Hu FB, van Dam RM, Liu S.** Diet and risk of type II diabetes: the role of types of fat and carbohydrate. *Diabetologia* Jul: 44(7): 805-17, 2001.

17. **Salmeron J, Hu FB, Manson JE, Stampfer MJ, Colditz GA, Rimm EB, Willett WC.** Dietary fat intake and risk of type 2 diabetes in woman. *Am J Clin Nutr* Jun; 73(60; 1019-26, 2001.

18. **Rivellese AA, Lilli S.** Quality of dietary fatty acids insulin sensitivity and type 2 diabetes. *Biomed Pharmacother* Mar: 57(2); 84-7, 2003.

19. **Pelikanova T, Kohout M, Valk J, Base J, Kazdova I.** Insulin secretion and insulin action related to the serum phospholipids fatty acid pattern in healthy men. *Metabolism* 38, 188-192, 1989.

20. Boden G. Fatty acids and insulin resistance. *Diabetes Care* 19: 394-395, 1996.

21. Manas Kaushik, Dariush Mozaffaroian, Donna Spiegelman, JoAnn E, Manson, Walter C, Willet and Frank B Hu. Long chain omega 3 fatty acids, fish intake, and risk of type 2 diabetes mellitus. *Am J Clin Nutr* 90; 613-20, 2009.

22. Lopez-Garcia E, Schulze MB, Manson JE et al. Consumption of (n-3) fatty acids in related to plasma biomarkers of inflammation and endothelial activation in women. *J Nutr* 134; 1806-11, 2004.

23. Adler AI, Boyko EJ, Schraer CD, Murphy NJ. Low prevalence of impaired glucose tolerance and diabetes associated with daily seal oil or salmon consumption among Alaska natives. *Diabetes Care* 17; 1498-501, 1994.

24. Fasching P, Ratheiser K, Waldhausl W et al. Metabolic effects of fish oil supplementation in patients with impaired glucose tolerance. *Diabetes* 40: 583-9, 1991.

25. Toft I, Bonaa KH, Ingebretsen OC, Nordoy A, Jenssen T. Effects of n-3 polyunsaturated fatty acids on glucose homeostasis and blood pressure in essential hypertension. *Ann Intern Med* 123; 911-8, 1995.

26. Giacco R, Cuomo V, Vessby B et al. Fish oil insulin sensitivity, insulin secretion and glucose tolerance in healthy people:is there any effect of fish oil supplementation in relation to the type of background diet and habitual dietary intake of n-6 and n-3 fatty acids? *Nutr Metab Cardiovasc Dis* 17; 572-8014, 15, 2007.

27. Lee DH, Lee IK, Song K et al. A strong dose-response relation between serum concentrations of persistent organic polluants and diabetes: results from the National Health and Examination Survey2. *Diabetes Care* 29; 1638-44, 1999-2002, 2006.

28. Gillingham LG, Harris-Janz S, Jones PJ. Dietary monounsaturated fatty acids are protective against metabolic syndrome and cardiovascular disease risk factors. *Lipids* Mar; 46(3); 209-28, 2011.

29. Yang ZH, Miyahara H, Mori T, Doisaki N, Hatanaka A. Beneficial effects of dietary fish oil-derived monounsaturated fatty acids on metabolic syndrome risk factors and insulin resistance in mice. *J Agric Food Chem* Jul 13; 59(13); 7482-9, 2011.

30. Lardinois CK. The role of omega 3 fatty acids on insulin secretion and insulin sensitivity. *Med Hypotheses* 24, 243-8, 1987.

31. Adler AI, Boyko EJ, Schraer CD, Murphy NJ. Lower prevalence of impaired glucose tolerance and diabetes associated with daily seal oil or salmon consumption among the Alaska Natives. *Diabetes Care* 17, 1498-501, 1994.

32. Murphy NJ, Schraer CD, Bulkow LR et al. Diabetes mellitus in Alaskan Yupik Eskimos and Athabsan Indians after 24 years. *Diabetes Care* 15, 1390-2, 1992.

33. Peskens EJ, Bowels CH, Kromhout D. Inverse association between fish intake and risk of glucose intolerance in normoglycemic elderly men and women. *Diabetes Care* 14, 935-41, 1991.

34. Nkondjock A, Receveur O. Fish–seafood consumption, obesity and risk of type 2 diabetes: an ecological study. *Diabetes Metab* 29, 635-42, 2003.

35. Katie A, Meyer M, Lawrence H, Kushi, David R, Jacobs Jr, Aaron R, Folsom. Dietary fat incidence of type 2 diabetes in older Iowa women. *Diab.Care* vol 24: 8, 1528-35, 2001.

36. Feskens EJ, Bowels CH, Kromhout D. Invesrse association between fish intake and risk of glucose intolerance in normoglycemic elderly men and women. *Diabetes Care* 1 nov 14(11): 935-41, 1991.

37. Yutaka Kiyohara, Akiko Shinohara, Isdao Kato, Tomoko Shirota, Michiaki Kubo, Yumihiro Tanizaki, Masatoshi Fujishima and Mitsuao Iida. Dietary factors and development of impaired glucose tolerance and diabetes in general Japanese population: *the Hisayama study Journal of Epidemiology* 13, 5, 251-58, 2003.

38. Montonen J, Knekt P, Jarvinen R et al. Whole-grain and fiber intake and the incidence of type 2 diabetes. *Am J Clin Nutr* 77, 622-9, 2003.