Medical Nutrition Therapy and the Prevention of Diabetes

a report by
Claude K Lardinois, **MD**, **FACP**, **FACN**

Professor of Medicine, University of Nevada School of Medicine, Founder, Chief Operating Officer, and Medical Director, Nevada Diabetes Association for Children and Adults

Claude K Lardinois, MD, FACP, FACN, is Professor of Medicine at the University of Nevada School of Medicine. He is also Founder, Chief Operating Officer and Medical Director of the Nevada Diabetes Association for Children and Adults (NDACA), a global non-profit organization dedicated to improving the lives of children and adults affected by diabetes through prevention, education, and service. He is a Fellow of the American College of Physicians (ACP) and the American College of Nutrition (ACN). Dr Lardinois' research interests include work in diabetes, hypertension, and dyslipidemia. He is particularly interested in the role of nutrition in diabetes management. He serves on the Board of Directors of the ACN and is Associate Editor of the *Journal of the American College of Nutrition*. Dr Lardinois has won several teaching awards from medical students and residents. He has given numerous clinical and scientific presentations and has written several peer-reviewed articles. Dr Lardinois is board-certified in internal medicine, endocrinology, and geriatrics.

Diabetes mellitus has become one of the great epidemics of the 21st century. It is estimated that 150 million adults worldwide are affected and that this number will double by 2025. Cumulative risk for developing diabetes in individuals born in 2000 in the US is 38% for females and 33% for males. Diabetes is the third leading cause of death when it is recognized that 80% of patients with diabetes die from cerebrovascular and cardiovascular disease (CVD). Obesity, changes in dietary habits, and a sedentary lifestyle are fueling the epidemic. The combination of physical inactivity (hypoactive foot) and overeating (hyperactive fork), known as 'foot and fork disorder', contributes substantially to the development of diabetes, primarily type 2. Reducing the burden of this devastating disease requires prevention programs that not only target the affected individual but also families, communities, schools, and workplaces. The public health importance of diabetes prevention is indisputable. The purpose of this review is to address several nutritional and lifestyle factors that can be implemented in order to reduce the diabetes epidemic.

Dietary Fiber and Wholegrain Intake

Several large prospective cohort studies have shown inverse associations between non-starch polysaccharides or dietary fiber intake and developing type 2 diabetes mellitus. Data from the Nurses Health Study (NHS) and the Health Professionals Follow-up Study (HPFS) showed an inverse relationship between cereal fiber and the development of diabetes. Similar findings were also found in the Iowa Women's Health Study (IWHS) and the Atherosclerosis Risk in Communities (ARC) study. Associations with diabetes were stronger for cereal fiber than for fiber sources from fruit and vegetables. A positive relationship has also been shown between wholegrain foods and risk of diabetes mellitus. Women in the IWHS consuming 33 servings of wholegrain foods per week had a 21% lower risk of developing diabetes compared with women who consumed less than 13 servings per week. Similar results were reported in the NHS and HPFS. These findings provide strong support that increasing dietary fiber sources from cereals and increasing wholegrain intake may decrease the development of diabetes in the general population.

Dietary Fat Intake

Polyunsaturated fats enhance insulin action, whereas saturated fats and diets with a high total-fat content decrease insulin sensitivity in animal studies. It is hypothesized that dietary fats affect the phospholipid composition of cell membranes in skeletal muscle and other tissues. Phospholipid cell membranes containing high concentrations of long-chained polyunsaturated fats, i.e. omega-3 fatty acids, demonstrate increased insulin sensitivity compared with a cell membrane containing saturated fatty acids. Substituting dietary saturated for monounsaturated fats impairs insulin sensitivity in healthy men and women. In the NHS a positive association between the development of diabetes and the intake of trans-fatty fats was observed, whereas an inverse association was observed with polyunsaturated fat intake. There was no association for total fat in the diet and risk of developing diabetes. These findings provide strong support that substituting saturated fats for mono-unsaturated and polyunsaturated fats in the diet may decrease the risk of developing diabetes.

Overweight and Obesity

Obesity has long been recognized as one of the strongest risk factors for the development of diabetes. Risk variance estimates obesity accounts for 60–90% of the risk. The rate of increase in overweight among young people is alarming. Since 1980 the percentage of children who are overweight has nearly doubled, and the percentage of adolescents who are overweight has nearly tripled. Just 10 years ago, type 2 diabetes was virtually unknown in children and adolescents. Currently, it accounts for almost 50% of new cases of diabetes in some communities. Multiple studies in widely different populations show a strong positive association between weight gain and the subsequent development of diabetes. In many studies, weight-loss improved glucose control in people with diabetes. There is also compelling evidence that abdominal adiposity is a more important risk factor for the development of diabetes than body mass index (BMI). Overweight people with abdominal apple-shaped adiposity are at greatest risk of developing diabetes compared with similar overweight people with

peripheral pear-shaped adiposity. Prospective studies of sustained weight-loss and the development of diabetes suggest that even modest weight-loss is associated with a significant reduced risk of diabetes. Excess energy consumption (hyperactive fork) fuels weight gain and subsequent obesity. Compelling evidence supports the notion that the most important factor contributing to the risk of diabetes is obesity. These findings provide strong support that even minor weight reductions in overweight individuals may have major beneficial effects on subsequent diabetes risk.

Vitamin D and Calbindin

Emerging evidence is showing an important role of vitamin D in diabetes prevention. Vitamin D deficiency predisposes individuals to type 1 and type 2 diabetes. Receptors for its activated form, 1,25-dihydroxyvitamin D3 (1,25(OH)2D3) have now been identified in pancreatic beta-cells and cells of the immune system. Intriguing correlations between geographical latitude and the incidence of type 1 diabetes have been described, and an inverse correlation between monthly hours of sunshine and the incidence of diabetes. An intake of 2,000IU of vitamin D during the first year of life diminishes the risk of type 1 diabetes. Furthermore, the presence of islet auto-antibodies in offspring was inversely correlated with maternal dietary vitamin D intake during pregnancy. Vitamin D deficiency is also linked to impaired glucose tolerance and type 2 diabetes in humans. Insulin secretion is inhibited by vitamin D deficiency. Receptors for the active form of vitamin D and the effector part of the vitamin D pathway is also present in the form of a vitamin D-dependent calcium-binding protein (calbindin). The expression of calbindin has been shown to protect beta-cells from cytokine-mediated cell death. Overwhelming clinical evidence exists showing that vitamin D deficiency is detrimental to beta-cell function, leads to glucose intolerance, and predisposes to type 2 diabetes. Shockingly, vitamin D insufficiency ranges from 32% in health professionals and up to 80% in nursing home patients. It is therefore important to recognize that vitamin D deficiency is common and undesirable not only for calcium and bone health, but also for carbohydrate metabolism. An intake of at least 1,000–1,200IU of vitamin D3 is required to maintain a normal 25-hydroxyvitamin level of 75nmol/L (30ng/mL). Current recommended daily allowances of 400–800IU for vitamin D3 are clearly inadequate.

Physical Activity

Physical inactivity (hypoactive foot) is another well recognized risk factor for the development of diabetes. Despite common knowledge that exercise is healthy, more than 60% of American adults are not regularly active, and 25% of the adult population is not active at all. Nearly half of young people aged 12 to 21 years of age are not vigorously active—this disturbing trend will continue to increase as an increasing number of schools eliminate physical activity from their curriculum. Moreover, although many people have enthusiastically embarked on vigorous exercise programs at one time or another, most do not sustain their participation. Physical activity has been shown to increase insulin-stimulated glucose utilization. Men who exercised regularly at moderate or vigorous intensity had a 35% lower risk of developing type 2 diabetes than men who were sedentary. In the NHS, walking was compared with vigorous activity. Participants who performed the most physical activity were 26% less likely to develop diabetes than those who were sedentary. Even among women who did not perform vigorous physical activity, those who walked were also 26% less likely to develop diabetes. These findings provide strong evidence that physical activity is associated with reductions in the risk of diabetes. The processes of developing and maintaining healthier habits are as important to study as the health effects of these habits. It is important for people to find their balance between food and physical activity and it is critical to stay within daily calorie needs. Daily physical activity is important with the appreciation that 60 minutes a day may be required to prevent weight gain and an additional 30 minutes a day may be required to sustain weight loss. Children and adolescents should be encouraged to be physically active for 60 minutes every day.

Cigarette Smoking

Cigarette smoking is well established as a causal factor for coronary heart disease (CHD) and stroke. What is not appreciated is that smoking also increases the risk of developing type 2 diabetes, which is another well-documented risk factor for heart disease. Several large prospective studies suggest that smoking is associated with the development of type 2 diabetes in men and women. Cigarette smoking is known to cause elevations in blood glucose concentration and current smokers have higher glycosylated hemoglobin concentrations compared with non-smokers. Biological mechanisms include insulin resistance, increased abdominal adiposity, and direct toxic effect on beta-cells. Insulin-stimulated glucose uptake is significantly lower in chronic cigarette smokers than in non-smokers. In addition, smokers tend to have lower BMI on average than non-smokers, but are more likely to have increased abdominal adiposity, which is associated with insulin resistance. Smokers also have higher triglycerides and lower high-density lipoprotein (HDL) cholesterol concentrations than non-smokers.

In the NHS, women who smoked more than 25 cigarettes per day had a 42% greater risk of developing diabetes than those who have never smoked. In the Physicians Health Study (PHS) men who smoked at least 20 cigarettes daily had a 70% greater risk of developing diabetes than participants who never smoked. Another 16-year prospective study in men reported similar results. Men who smoked had a 74% greater risk of developing diabetes than those who had never smoked. These findings provide compelling evidence that cigarette smoking cessation has to be a top national healthcare priority.

Alcohol Consumption

Alcohol consumption is a lifestyle behavior that, it has been suggested, is important with respect to the risk of developing diabetes. Several studies, primarily in men, report a U-shaped relationship indicating a decreased risk of diabetes with moderate alcohol consumption

BMI and the development of diabetes. Among lean men (BMI less than $<22kg/m^2$), heavy drinking was associated with a 2.48 times increased risk of diabetes when compared with non-drinkers. However, among men with a BMI $>22kg/m^2$, moderate drinking was associated with a 42% decrease in the risk of developing diabetes. Future studies with wider ranges of BMI ($20–40kg/m^2$) are needed before a conclusion of whether there is a link between BMI, alcohol consumption, and risk of developing diabetes can be reached. Caution should also be made when it comes to classifying the type of diabetes associated with alcohol consumption. Published studies imply that the link between alcohol consumption is with type 2 diabetes, although that assumption may be incorrect. The hallmark of type 2 diabetes is insulin resistance associated with obesity and a strong family history of type 2 diabetes. Notably absent or infrequent is a family history of type 2 diabetes in those individuals who are thin (BMI $<22kg/m^2$) who develop diabetes from

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compared with both abstaining and excessive drinking; however, heavy drinking was not shown to increase the risk of diabetes in other studies. These results suggest that other factors than just the amount of alcohol consumed may be important confounders or modifiers of the relationship, i.e. sex and BMI. A recent study of older women supports the evidence of a decreased risk of diabetes with alcohol consumption. Compared with abstainers there was a 22% reduction in diabetes for women consuming 30–70g alcohol per week and even women consuming 70–140g alcohol per week had a 14% reduction in diabetes; however, women consuming more than 210g alcohol per week had the same risk compared with abstainers. These finding supports a U-shaped relationship between alcohol consumption and diabetes, which is similar to studies reported in men. Most studies addressing BMI have failed to show any differences in the risk of developing diabetes between individuals with low or high BMI and alcohol consumption. These studies must be interpreted with caution. The BMI for most of the studies ranged between $25–30kg/m^2$. The difference between 'low' and 'high' in such a narrow BMI range may explain why no differences were observed. The Osaka Health Survey in Japanese men provided compelling evidence linking

heavy alcohol consumption. These individuals are remarkably insulin sensitive (not insulin resistant) suggesting that they have a type of diabetes called 'alcohol-associated diabetes mellitus', which is distinctly different from type 2 diabetes. Alcohol cessation is paramount in these individuals to reduce the toxic effects of alcohol on beta-cells. Although further studies of alcohol consumption and developments of diabetes are needed, several long-term studies support the evidence of a decreased risk of diabetes with moderate alcohol consumption.

Closing Remarks

The preponderance of evidence demonstrates that diabetes, particularly type 2, is a preventable disease. Lifestyle modifications including more physical activity (more foot) and reduce caloric intake (less fork) must be encouraged. Prevention of even a small number of cases would have a major impact on reducing healthcare costs. ■

A version of this article containing references and a graphic can be found in the Reference Section on the website supporting this briefing (www.touchendocrinedisease.com).