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**Effects of Exercise and Diet on Chronic Disease Part IV**
**Diabetes**
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**Your Life Your Health**
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We continue our summary of the review article in the November, 2005 issue of *Journal of Applied Physiology* entitled, "Effects of exercise and diet on chronic disease." Previously, we have looked at the effect of diet and exercise on heart disease and hypertension. Today, we review their effect on diabetes.

Normally over 75% of blood glucose is cleared into muscle by insulin, and insulin resistance in muscle is the primary defect leading to diabetes. Harris noted that >40% of the elderly meet diagnostic criteria for diabetes or impaired glucose tolerance, an estimate matching those provided by the Centers for Disease Control, in which 40% of US adults have impaired fasting glucose (defined as blood glucose above 100 mg/dl after a twelve hour fast) and/or impaired glucose tolerance (defined a a blood glucose between 140-200 two hours after a 75 gram glucose load).

Diabetes has increased dramatically and to epidemic levels in recent years. The estimated prevalence of diabetes increased 600% from 1958 to 1993 and has continued to increase in the last 10 years. Currently, just under 20 million people in the United States have diabetes, with 18% of those 60 yr or older having the disease. **Recently, Narayan estimated the lifetime risk of developing diabetes in individuals born in the year 2000 at 32.8% for men and 38.5% for women, with risk in Hispanic women exceeding 50%.**

Although traditionally diabetes was regarded as a chronic disease seen in older adults and was originally coined "adult-onset diabetes," evidence estimates that, before 1992, 4% of all newly diagnosed cases of diabetes occurred in those from birth to age 19, but in 1994 this age group accounted for 16% of all $^{newly}$ diagnosed cases, and an estimated 10-fold increase has occurred from 1982 to 1994.

Those diagnosed in 1994 presented with diabetes at an average age under 14 and with an average Body Mass Index (BMI) in excess of 37 $kg/m^2$. A BMI of 37 represents a person:

- five feet ten inches tall who weighs 260 pounds
- five feet tall who weighs 190 pounds
- four feet tall who weighs 126 pounds

As early as 1935, lifestyle factors were implicated to play a role in diabetes when Himsworth reported that rates of diabetes were higher in those with higher fat intakes. Evidence that diabetes is primarily a lifestyle disease comes from Eaton and Konner, who pointed out that hunter-gatherer societies exhibit a prevalence of diabetes at 1–2% vs. as high as 10% in industrialized nations.

Additionally, migration studies demonstrated the role of lifestyle factors in chronic disease, as Japanese migrants living in Hawaii had an elevated risk of diabetes compared with their counterparts living in Hiroshima. Although caloric intake was not different, consumption of animal fat and simple carbohydrates was greater and high-fiber carbohydrates and physical activity were lower in the migrants.

Genetic/environment interaction in the causing of diabetes is shown in studies comparing Pima Indians living in rural Mexico and following a traditional Pima lifestyle, with Pima Indians living in Arizona, consuming a Westernized diet, and maintaining a more sedentary lifestyle. Despite the similarity in genetic background of these two Pima communities, the Arizona Pimas, living in an "affluent" environment, have markedly higher rates of obesity and diabetes than the Mexico Pimas, living a "traditional" lifestyle, characterized by a diet including less animal fat and more complex carbohydrates and by greater energy expenditure in physical labor. Other examples of populations exposed to a Westernized lifestyle and exhibiting high rates of diabetes include Micronesians in Nauru, Wanigela in New Guinea, and Australian Aborigines, among others.

In the Nurses' Health Study, 91% of diabetes cases observed over a 16-yr follow-up could be attributed to lifestyle factors, such as a poor diet and physical inactivity. In a prospective study of 42,504 male health professionals, a prudent diet, characterized by higher intakes of vegetables, fruits, fish, poultry, and whole grains, was associated with a lower risk of diabetes (relative risk 0.84), whereas a high Western diet, characterized by higher intakes of processed and red meat, high-fat dairy, refined grains, sweets, and desserts, was associated with an increased risk (1.59).

When the Western diet pattern was combined with low physical activity, risk increased further (1.96). In Native Canadians, a higher prevalence of impaired glucose tolerance and diabetes is associated with consumption of foods high in simple sugar and fat and low in fiber. Regarding specific dietary components, dietary fiber consumption is associated with reduced diabetes risk and lower fasting insulin. Whole grain consumption is inversely associated with risk of diabetes, and substituting whole grain for refined grains is also associated with decreased risk.

In the Nurses' Health Study, a higher consumption of refined grain foods such as white bread and rice, desserts, muffins, pancakes, and breakfast cereals was associated with an increased risk of diabetes. When data from several cohort studies are pooled, the estimated relative risk from high whole grain consumption is 0.70. Fiber and whole grains may also explain, in part, the effect of glycemic load (for an explanation of this

concept see “Glycemic Load” at www.jameslhollymd.com under Your Life Your Health) on diabetes risk.

In both the Nurses’ Health Study and Health Professionals Follow-up Study, diabetes incidence increased with higher glycemic load. In addition, omega-3 fatty acids may affect diabetes risk. Fish consumption has been shown to reduce the risk of glucose intolerance. On the other hand, after 14 yr of follow-up, consumption of trans-fatty acids was associated with increased risk of diabetes in the Nurses’ Health Study.

Several studies indicate that low fitness increases the risk of diabetes and increased physical activity is effective in preventing diabetes. In men with diabetes, low cardiorespiratory fitness and physical inactivity independently predict mortality risk compared with fit men. In the CARDIA study, those not obese at the onset of the study with low fitness were 3.66 times more likely to develop diabetes compared with those with high fitness, and increasing fitness during the 7-yr study was associated with a reduced risk of diabetes (risk ratio of 0.4).

In the University of Pennsylvania Alumni Health Study, 5,990 men were surveyed and the amount of leisure-time physical activity was inversely related to the development of diabetes; each additional 500 kcal/wk of physical activity was associated with a decrease in risk of 6%. Manson examined the association between regular vigorous exercise and the subsequent incidence of diabetes in 87,253 US women aged 34–59 yr. During an 8-yr follow-up, 1,303 cases of diabetes were noted, and women who engaged in vigorous exercise at least once/wk had an age-adjusted relative risk of 0.67 compared with women who did not exercise weekly.

The Physicians’ Health Study followed 21,271 men 40–84 yr of age and free of diagnosed diabetes for 5 yr; men who exercised at least once/wk had an age-adjusted relative risk for diabetes of 0.64 compared with those who exercised less frequently.

In addition, it is interesting to note that there is also a powerful effect of television watching on risk of diabetes, as it has been reported among 37,918 men that, compared with 0–1 h/wk, >21 and >40 h/wk of television watching are associated with relative risks of 2.16 and 2.87, respectively, for development of diabetes over a 10-yr period. In fact, it has been estimated that average time viewing television for US men is 29 h/wk and for women 34 h/wk.

***Intervention studies and mechanisms***

**Interventions incorporating physical activity, diet, or a combination of both have been documented to reduce progression to diabetes and reverse existing diabetes**. Residents of Da Qing, China, were screened for impaired glucose tolerance and diabetes, and the 577 that were classified as having impaired glucose tolerance were randomized to control, diet, exercise, or diet plus exercise groups.

After 6 years, the interventions were associated with reductions in risk of developing diabetes of:

- 31% for diet,
- 46% for exercise, and
- 42% for diet and exercise

In the Malmo Preventive Trial, 6,956 men underwent health screening at 48 yr of age, and 41 subjects with early-stage diabetes and 181 subjects with impaired glucose tolerance were selected for long-term lifestyle intervention. After the 5-yr protocol:

- cardiopulmonary fitness increased by 10–14% in the intervention group and decreased by 5–9% in the control group.
- Glucose tolerance was normalized in >50% of subjects with impaired glucose tolerance
- >50% of the diabetic patients were in remission after a mean follow-up of 6 years.

At 12-yr follow-up, the mortality rate in the intervention group was similar to those with normal glucose tolerance and 50% lower than those with impaired glucose tolerance given routine treatment.

In an exercise-only intervention, resistance training decreased glycosylated hemoglobin levels; blood pressure and diabetes medication dose were lowered in 72% of trainees, whereas over the 16-wk study, blood pressure increased and medication dose increased by 42% in the control group.

Two large randomized intervention trials, the Finnish Diabetes Prevention Study and the Diabetes Prevention Program in the United States, both demonstrate that lifestyle change can significantly reduce the risk of developing diabetes in individuals with impaired glucose tolerance. After an average 3-yr follow-up, the risk of diabetes was reduced 58% in the intervention group, despite minimal weight loss (3.5 kg after 2 yr). The authors also pointed out that a target of ≈4 h of exercise per week reduced the risk of diabetes in those who did not lose weight.

***Summary***

Diabetes prevalence has increased dramatically over the past two decades, contributed to by changes in activity levels (exercise training, television viewing, computers/internet, etc.) and diet. This problem is exemplified by removal of "adult onset" from its description, given its prevalence in today’s children and adolescents, a group in whom this disease was essentially nonexistent previously. Exercise training (aerobic and/or resistance) has been shown to reduce progression to diabetes and reverse overt diabetes. Combined interventions have documented reversal of existing diabetes, even in those on insulin therapy, albeit less than with oral hypoglycemic therapy. Lifestyle interventions have been highlighted by the Finnish and Diabetes Prevention Program trials, which unequivocally document that progression to diabetes in those with elevated fasting

glucose or impaired glucose tolerance can be mitigated by exercise and diet and are superior to drug therapy. The major mechanism for risk reduction appears to be improvement in insulin sensitivity.

Remember, it is your life your health. Next week, the benefit of diet and exercise in preventing certain cancers.