

Plasma vitamin C level, fruit and vegetable consumption, and the risk of new-onset type 2 diabetes mellitus: the European prospective investigation of cancer--Norfolk prospective study.

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BACKGROUND: Epidemiologic studies suggest that greater consumption of fruit and vegetables may decrease the risk of diabetes mellitus, but the evidence is limited and inconclusive. Plasma vitamin C level is a good biomarker of fruit and vegetable intake, but, to our knowledge, no prospective studies have examined its association with diabetes risk. This study aims to examine whether fruit and vegetable intake and plasma vitamin C level are associated with the risk of incident type 2 diabetes. **METHODS:** We administered a semiquantitative food frequency questionnaire to men and women from a population-based prospective cohort (European Prospective Investigation of Cancer-Norfolk) study who were aged 40 to 75 years at baseline (1993-1997) when plasma vitamin C level was determined and habitual intake of fruit and vegetables was assessed. During 12 years of follow-up between February 1993 and the end of December 2005, 735 clinically incident cases of diabetes were identified among 21 831 healthy individuals. We report the odds ratios of diabetes associated with sex-specific quintiles of fruit and vegetable intake and of plasma vitamin C levels. **RESULTS:** A strong inverse association was found between plasma vitamin C level and diabetes risk. The odds ratio of diabetes in the top quintile of plasma vitamin C was 0.38 (95% confidence interval, 0.28-0.52) in a model adjusted for demographic, lifestyle, and anthropometric variables. In a similarly adjusted model, the odds ratio of diabetes in the top quintile of fruit and vegetable consumption was 0.78 (95% confidence interval, 0.60-1.00). **CONCLUSIONS:** Higher plasma vitamin C level and, to a lesser degree, fruit and vegetable intake were associated with a substantially decreased risk of diabetes. Our findings highlight a potentially important public health message on the benefits of a diet rich in fruit and vegetables for the prevention of diabetes.

Commentary from Dr. Thomas Levy:

This study is especially impressive since it utilizes plasma vitamin C measurements in making its evaluation of the incidence of diabetes mellitus in a test

population. Trying to evaluate by questionnaire how much fruit and vegetables have been consumed is imprecise at best. As well, different digestive tracts have variable degrees of efficiency in the amount of nutrition absorbed and assimilated. However, in looking at the relation between plasma vitamin C levels and the likelihood of having diabetes mellitus the data makes a compelling case.

However, even with the imprecision inherent in evaluating fruit and vegetable intake, it was found that women and men who had the highest intake had a 22% reduction in their risk of developing type 2 diabetes. The upper 20% of women consumed 58% more fruits and vegetables than the bottom 20%, and the upper 20% of men consumed 43% more than the bottom 20%.

When looking at plasma (blood sample) vitamin C levels, the data was even more compelling. Men and women with the highest vitamin C levels had a 62% reduction in their risk of developing type 2 diabetes over those subjects with the lowest vitamin C levels. The study was sizeable, following 21,831 men and women over a 12-year period.

Vitamin C and glucose are interrelated in a number of important ways. Vitamin C is involved in regulating insulin metabolism in the pancreas. Also, vitamin C, in animals that have the capability (not man), utilize glucose as the substrate for a four sequential enzyme process in the liver resulting in vitamin C. This utilization of glucose by animals in vitamin C synthesis is one important reason why diabetes is not a chronic disease that one sees to any significant degree in wild animals. Finally, sufficient vitamin C intake can reflexly stimulate insulin release, pushing both available glucose and vitamin C inside the cells. When vitamin C levels are low, it is logical that glucose metabolism will become chronically impaired, and if it is impaired severely enough and long enough, diabetes will be the logical outcome.