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FRUIT AND VEGETABLES CONSUMPTION AND TYPE 2 DIABETES PREVENTION

In this issue of the Global Fruit & Veg Newsletter, three summary reports are presented.

Kjell Olsson et al. examined 18 years' risk of type 2 diabetes (T2D) in relation to carbohydrate intakes in 26 662 Swedish men and women. High intakes of monosaccharides and fruits were associated with lower T2D risk, while intakes of disaccharides and sweets associated with higher risk. In men, intakes of vegetables were associated with lower risk of T2D.

Nita Forouhi *et al.* examined associations of plasma concentrations of vitamin C and six carotenoids with the incidence of T2D in a large EPIC-InterAct case-cohort study in 8 European countries. Higher concentrations of vitamin C and total carotenoids were associated with lower risk of T2D. Self-reported fruit and vegetables intake was higher (508 g/d) in individuals with the highest composite biomarker score based on vitamin C and carotenoids concentrations than in the lowest score (274 g/d) of five biomarker categories. The authors conclude that, it is fruit and vegetables intake as such not vitamins that is beneficial in diabetes prevention.

The cross-sectional study by Xu Jia *et al.* summarized by Jean-Michel Lecerf reported whether the impact of genetic risk score (GRS) of T2D is modified by fruit and vegetables intake in Chinese population. Main finding was that a higher fruit and vegetables intake seems to overcome the genetic risk, while a bad combination was low F&V intake with high GRS.

In experimental studies, high intake of fructose is linked with the risk of fatty liver and high serum triglycerides, but plenty use of fruit and vegetables, as the present studies confirm, is good for health. Goal for fruit and vegetables is 500 g a day – in line with new results of the EPIC-InterAct Study.

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Carbohydrate-rich foods and incidence of type 2 diabetes - What associations do we see?

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Worldwide, about 460 million adults were suffering from diabetes in 2019, with nine out of ten diabetes cases being of type 2[1]*. Diet is one of the main modifiable risk factors for type 2 diabetes, due to its effect on post-prandial glucose levels, insulin resistance and obesity*[2]*. Dietary carbohydrates, in particular, have long been predicted to be associated with risk of type 2 diabetes. However, the metabolic effect differs between different carbohydrates and carbohydrate-rich foods*[3]*.*

This study aimed to analyze the association between intakes of six types of carbohydrates and thirteen carbohydrate-rich foods with incident type 2 diabetes. Dietary intake in 26,622 participants (61 % women) in southern Sweden was assessed at baseline (1991–1996) by using a modified diet history method. During mean follow-up of 18 years, 4,046 cases were identified.

Characteristics of type 2 diabetes cases

During 18-years of follow-up, a greater proportion of men developed type 2 diabetes (18.8 % vs. 12.9 %). Compared to non-cases, type 2 diabetes cases in both men and women had greater BMI, waist circumference and percentage of body fat at baseline. They were also more likely to report low physical activity and less likely to have a university degree.

Fruit was inversely associated with type 2 diabetes in both sexes - vegetables in men only

After adjusting for potential confounders, such as lifestyle (physical activity, alcohol habits, smoking etc.), BMI and dietary factors, these were the results when comparing the highest vs the lowest quintile of intake:

- Intake of fruits (median intake in the highest quintile = 357 g/day) and monosaccharides (i.e. glucose, fructose and galactose) were inversely associated with incident type 2 diabetes. The inverse association between monosaccharides and type 2 diabetes may be partly explained by fruit intake, as there was a strong correlation between these two variables.
- Disaccharides (i.e. sucrose, lactose and maltose) and sweets were both positively associated with incident type 2 diabetes.

After stratification by sex, vegetable intake (median intake in the highest quintile = 301 g/day) as well as intake of marmalade/honey/jam were inversely associated with incident type 2 diabetes in men only, while chocolate intake was positively associated in women only.

In addition, there was a significant inverse trend between intake of whole grains and incident type 2 diabetes before adjusting for dietary confounders, which was attenuated after adjustment.

Likewise, fiber intake was inversely associated with incident type 2 diabetes in the basic model. However, after further adjustment, no associations were found.

How do we explain the protective effect from fruits and vegetables against type 2 diabetes?

Fruits and vegetables may both protect against type 2 diabetes. Their protective effects are likely due to their low energy density as well as their content of fiber and polyphenols (in particular flavonoids). Non-linear inverse associations with type 2 diabetes risk were found for both polyphenols and flavonoids in a recent meta-analysis. However, more studies are needed to confirm this association[4]. In addition, the role of fruit and vegetable intake in the prevention of other non-communicable diseases, such as cardiovascular diseases, as well as all-cause mortality, has already been well established[5].

In conclusion, higher intakes of monosaccharides and fruits were associated with a reduced risk of type 2 diabetes, while positive associations were found for disaccharides and sweets. Additional sex-specific associations were also identified, such as an inverse association for vegetable intake in men. Future studies are needed to explore these associations further.

Based on: Olsson K, et al. Associations of carbohydrates and carbohydrate-rich foods with incidence of type 2 diabetes. Br J Nutr. 2020 Dec 23;1-11.

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Blood biomarkers help to clarify the link between fruit and vegetable consumption and the risk of type 2 diabetes

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The prevalence of type 2 diabetes has been increasing globally over recent decades, boosted by rapid urbanization and dramatic changes towards poor nutrition and sedentary lifestyles[1]. The prevention of type 2 diabetes is an urgent public health priority. The consumption of fruit and vegetables is considered to be a key part of a healthy diet for the prevention of chronic diseases such as heart disease, stroke and cancer, but the evidence for type 2 diabetes has been inconsistent and inconclusive[2,3,4]. Since asking people about their dietary intakes is prone to misreporting and error, getting evidence from objective markers of fruit and vegetable consumption can improve research.

Thus, researchers at the MRC Epidemiology, Cambridge, together with a group of European researchers conducted a prospective study – the EPIC InterAct Study*. They measured levels of nutritional biomarkers in the blood - vitamin C and six different carotenoids (α carotene, β carotene, lycopene, lutein, zeaxanthin and β cryptoxanthin), as indicators of fruit and vegetable intake. A composite biomarker score was also generated by calculating the average of standardized values of vitamin C and the six individual carotenoids. They then examined the association between the individual and combined biomarkers with new-onset type 2 diabetes that developed over follow-up of participants who did not initially have diabetes.

A total of 340,234 people from eight European countries* were followed up, among whom 10,000 individuals developed type 2 diabetes over approximately 10 years and a representative sample of 13,500 individuals remained free of diabetes. By measuring the nutritional biomarkers in approximately 23000 people with and without type 2 diabetes this study is the largest of its kind in the world.

Association between fruit and vegetables intake and blood biomarkers plasma vitamin C and carotenoids

Dietary intake of fruit and vegetables across a wide variety were all positively associated with the nutritional biomarkers plasma vitamin C, total carotenoids, and the composite biomarker score. In summary, the average fruit and vegetable intake was the lowest when the level of the composite biomarker score was the lowest, and conversely fruit and vegetable intake was the highest when the biomarker score was the highest. On average, the link between intake and biomarker levels indicated that every one standard deviation unit higher of the composite biomarker score was equivalent to 66 g/day higher total fruit and vegetable intake.

Association of plasma vitamin C, total and individual carotenoids with incident type 2 diabetes

The study found that the higher the composite biomarker score level the lower the risk of developing diabetes in the future. Compared with those people who were in the lowest fifth of the distribution of the composite biomarker score, those in increasing fifths of the biomarker score (2nd, 3rd, 4th and highest categories) had a reduced relative risk of diabetes by 23%, 34%, 41% and 50% respectively.

Looked at another way, we also found that a difference in the composite biomarker score equivalent to a 66 g/day difference in fruit and vegetable intake could potentially cut the relative risk of type 2 diabetes by a quarter. Since each portion of fruit or vegetable is considered to be around 80g in the dietary guidelines that recommend eating "5-a-day", this means that higher habitual consumption of even one portion per day would have potential health benefits.

Our findings are based on an observational study, not a dietary intervention, hence we are cautious in implying a causal relationship. However, by using objective biomarker levels to indicate fruit and vegetable intake and with consistent findings across different European countries, our study adds meaningfully to the evidence base. The important take-away message is that even just a small increase in consumption of fruit and vegetables is linked with a reduced risk of developing type 2 diabetes.

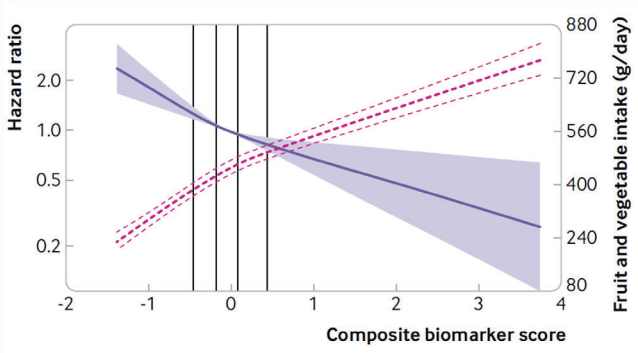

Figure 1: Associations of plasma composite biomarker score with incident type 2 diabetes (In purple: hazard ratios for the association of the composite biomarker score with type 2 diabetes; In red: association of the composite biomarker score with fruit and vegetable intake)

** The European Prospective Investigation into Cancer and Nutrition (EPIC)-InterAct cohort included participants from eight European countries: Denmark, France, Germany, Italy, Netherlands, Spain, Sweden, and UK.*

Based on: Ju-Sheng Zheng et al. Association of plasma biomarkers of fruit and vegetable intake with incident type 2 diabetes: EPIC-InterAct case-cohort study in eight European countries. BMJ. 2020;370:m2194.

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Interaction between genetic predisposition to diabetes and fruit intake

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The occurrence of type 2 diabetes is related to genetic factors as well as lifestyle factors, in particular an unbalanced diet combined with a sedentary lifestyle and abdominal weight gain. Hundreds of polymorphisms have been identified as being associated with the risk of diabetes. However, gene-diet interactions have not yet been widely studied. It is known that eating fruit has a favourable effect on the risk of diabetes, probably due to its high levels of micronutrients and phytochemicals and low energy density, and probably also since it replaces foods with low nutritional value and high energy density.

This study aimed to determine interactions between the intake of fresh fruit and a genetic risk score (GRS) based on 34 variants associated with diabetes in East Asia. It was a cross-sectional study focusing on 11,657 subjects aged 40 or over in the city of Shanghai, China.

Fruit intake was established based on a food frequency questionnaire for the past 12 months. The risk of type 2 diabetes, fasting and 2-hour postprandial glucose levels and glycosylated haemoglobin A1c associated with the GRS and with each single nucleotide polymorphism (SNP) were tested. Fresh-fruit intake was classified into three levels (< once/week – one to three times/week – and > three times/week). The GRS was divided into three tertiles (1, 2 and 3). The multivariate analysis was adjusted for the following variables: age, gender, BMI, systolic and diastolic blood pressure, lipid parameters, smoking, alcohol, physical activity, and other dietary factors.

Fruit intake reduces the risk of type 2 diabetes

The risk of type 2 diabetes increased regardless of fruit intake when the GRS increased. However, for each GRS tertile, it decreased when fruit intake increased. Moreover, it decreased even more sharply when the GRS was high. Therefore, the lowest risk was observed for fruit intake > three times/week and a GRS in tertile 1; the risk was highest for fruit intake < once/week and a GRS in tertile 3 (it was five times higher). It decreased to 1.72 for a GRS in tertile 3 when fruit intake was high (Table 1).

Table 1: Risk of type 2 diabetes based on fruit intake frequency and the GRS tertile

		GRS tertile		
		Tertile 1	Tertile 2	Tertile 3
Fruit intake frequency	< once/week	2.30	3.50	5.15
	one to three times/week	1.37	1.71	2.52
	> three times/week	1.00	1.45	1.72

Eating fruit further reduces the risk of type 2 diabetes when the genetic risk is high. However, in all cases, regardless of the genetic risk, eating fruit reduces the risk of type 2 diabetes. Lastly, benefits are observed even with low fruit intake (one to three times a week)!

Based on: Xu Jia et al. Fruit intake, genetic risk and type 2 diabetes: a population-based gene-diet interaction analysis. Eur J Nutr. 2021 Jan 5.