Is Consumption of 100% Orange Juice a Risk Factor for Overweight and Diabetes?

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Abstract: Much epidemiological research confirms a correlation between a high consumption of sugar sweetened beverages and obesity, diabetes and cardiovascular diseases. In many of these studies, soft drinks, fruit drinks with added sugars and 100% fruit juices without added sugars were considered as one separate category and the total consumption was calculated cumulatively. Being able to make statements about the effects of individual types of drinks, as present in these clusters, is therefore impossible. However, recent data from well-controlled studies and meta-analyses on consumption of 100% fruit juice show that there is no effect on diabetes risks. Adults and children who choose to drink 100% juice appear to have a healthier lifestyle, consume better quality food and usually have a more favorable body weight. Although 100% fruit juice in relation to soft drinks contains a range of nutrients that are considered to be beneficial for health, the associated positive effects can be nullified by high sugar intake, in case of excessive consumption. That is why a golden rule can be applied: "100% fruit juice, as part of a healthy diet, is a healthy choice provided that you do not consume more juice than present in max. 1-3 fruits at a time. In the case of orange juice, this corresponds to a champagne glass full of juice (100-150ml). In this respect 100% fruit juice should be perceived as a nutritional drink that can be consumed with a meal and not as a thirst quencher.
Keywords: sugars, fructose, fruit juice, diabetes, overweight

Preface:

Many epidemiological studies have been conducted into the relationship between the consumption of sugar sweetened beverages (SSBs) and health. Many of these studies (for example Wang et al. (1), and Wojcicki et al. (2))found a correlation between increased consumption of SSBs and obesity, diabetes and cardiovascular disease, indicating that a frequent consumption of SSBs is one of a cluster of factors that mutually represent a generally poor life style which also is characterized by consuming more snack foods and alcohol, low fruit, vegetable and fibers intakes and low levels of physical activity. These factors, in concert, cause a positive energy balance, which, when being persistent leads to weight gain and associated chronic diseases. (3)(4)(5) . In many of the epidemiological studies, showing a relation with the incidence of overweight, diabetes and cardiovascular disease (CVD) with increasing intakes, soft drinks, fruit drinks with added sugars and 100% fruit juices without added sugars were considered as a one single category. The effects of a high heterogeneity in the SSB definition on the final conclusions has been discussed by Bucher della Torra et al. (6) who

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state that in some cases SBBs were even not distinguished from artificial sweetened beverages, which contain no added sugars. In one case drink intake was accurately measured and weighed but "soft drinks" were defined as "soft drinks, light soft drinks and fruit drinks" and the sum of these was taken for the data analysis and resulting conclusions. In another case even milkshakes and liquid yogurt (to which sugar was added) were included in the same category as SSBs, and this was taken for the data analysis. In another case, even the consumption of milkshakes and liquid yogurt (with added sugars) was included in the same category as SSBs. This makes it impossible to make statements about the effects of individual types of drinks within these categories.

It goes without saying that such an approach makes it impossible to make statements about the effects of individual types of drinks, within the group of mutually included drinks in the analysis. However, analyses of available studies in which soft drinks or fruit drinks with (a high content) of added sugars on the one hand, and 100% fruit juice without added sugars on the other hand were studied as separate categories makes it possible to quantify and qualify orange juice (OJ) consumption in terms of health and disease risks. These studies confirm the occurrence of unfavorable effects due to a frequent consumption of SSBs and fruits drinks with added sugars. Consumption of 100% OJ, however, did not appear to result in negative health effects or increased risk of weight gain and type 2 diabetes (7-10).

What do recent meta-analyses show?

Xi et al. (11) carried out a systematic review and meta-analysis of the results of studies that were found to be of good quality. They describe 8 major studies, 4 of which are related to the association between extra sweetened fruit drinks (with added sugars) and the risk of diabetes type 2 diabetes (191,686 participants, including 12,375 individuals who developed with type 2 diabetes) and four other studies on the effects of 100% fruit juice (137,663 participants among which 4,906 cases of diabetes developed). It turned out that a higher intake of fruit drinks with added sugars significantly increased the risk of type 2 diabetes (RR = 1.28, 95% CI = 1.04-1.59, p = 0.02). However, in the case of consumption of 100% fruit juice (without added sugars), there was no effect on diabetes risk (RR = 1.03, 95% CI = 0.91-1.18, p = 0.62). These observations are in line with those of an intervention study by Ribeiro et al (12) who found that individuals who were following a low-calorie diet, and were allowed to consume 100% orange juice experienced weight loss and an improvement of metabolic risk factors.

Lee et al (13) studied the effects of added sugars (ASs) vs. naturally occurring sugars (NOSs) in foods and drinks, on measures of central adiposity.
Evaluated beverage sources of liquid sugars included soft drinks, energy drinks, fruit juices, sweetened milks and sweetened coffees and teas; intake of solid sugars from food sources was estimated as the difference between total sugar intake and the estimate of sugar intake from beverage sources. NOSs were those consumed in fruits, vegetables and their juices. ASs are defined as all non-dairy sugars contained in candies, sweetened beverages, sweetened grain products and dairy desserts such as ice cream and pudding. It was observed that both liquid and solid ASs were associated with increased waist circumference, but

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there was no significant association, in any of the models used, between NOSs consumption and waist circumference. The authors concluded that the association between dietary sugars and adiposity varies by the type and form of the sugars consumed. While consumption of ASs appears to have a unique and independent effect on central adiposity, the association between AS and BMI (as measure of total adiposity) is mediated by total energy intake. NOSs in foods and beverages do not appear to increase adiposity at the levels consumed by study participants.

In the light of other studies showing that the frequent consumption of beverages sweetened with added sugars causes overweight, while this effect is not observed in persons consuming 100% fruit juice (Sievenpiper (4), fig 1), the above mentioned effects on body weight and diabetes risk factors leads to the question ' why not'?

Possible reasons for this may be the relatively low blood glucose increase after drinking 100% juice (low glycemic response and glycemic index, see fig. 2 and table 1, and the relatively high content of polyphenols (substances not present in SSBs) that have a beneficial effect on the reduction of oxidative stress and inflammation (see below). In addition, it appears that people who choose to drink 100% juice maintain a healthier lifestyle, including less alcohol use, less smoking and more physical exercise than non-consumers. They usually have a more favorable body weight (expressed as a lower Body Mass Index -BMI) (14). As a result, the quality of the daily diet also appears to be better as has been observed in both children and adults. (5, 15-19).

In the context of the above it is important to mention that observational research only shows correlations but never demonstrates causality. In this respect it should be emphasized that the choice to consume pure juice can be a sign of having a lifestyle in which also other healthy choices are being made. The overall effect of several favorable lifestyle factors can synergistically lead to beneficial effects on health.

Source	Cohort comparisons	Participants	Cases	Median Follow-up	Risk ratios (95% CI)	I^2
Foods						
SSBs[10]	9	310,819	15,043	10y	1.26 (1.12, 1.41)	66%*
SSBs (fruit drinks)[11]	4	191,686	12,375	19y	1.28 (1.04, 1.59)	43%
100% Fruit juice[11]	4	137,663	4906	10y	1.03 (0.91, 1.18)	6%
Cakes, cookies[13]	8	16,154	778	16y	0.96 (0.86, 1.07)	35%
Fruits[14]	11	424,677	22,995	11y	0.93 (0.88,0.99)	0%
Sugars						
Total sugars[12]	13	134,822	13,906	12y	0.88 (0.74, 1.06)	76%*
Total sucrose[12]	8	213,838	3829	6y	0.89 (0.80, 0.98)	1%
Total fructose[12]	6	129,478	3613	7y	1.04 (0.84, 1.29)	71%*

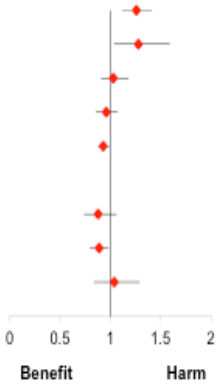

Fig 1- In this meta-analysis, 100% fruit juice was separated from soft drinks and juice-based beverages with added sugars. For clarification, the vertical line represents the NO effect line and the area to the left and right of this line concerns resp. reduction or increase

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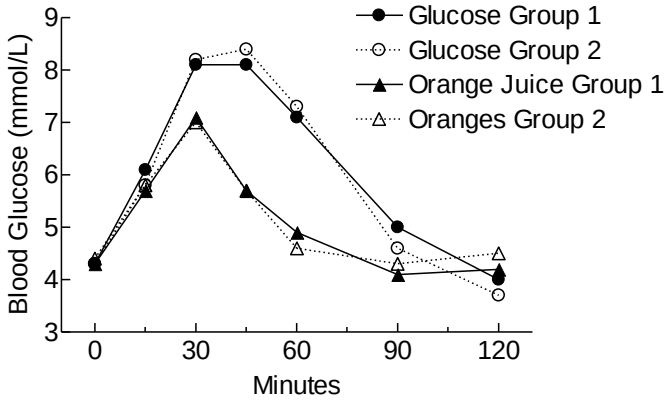
of the risk of developing diabetes. Soft drinks (SSBs) or fruit drinks with added sugars (fruit drinks) increase the risk of diabetes, whereas 100% juice has no effect (source (4, 20). "Reproduced with permission from Prof Dr J.Sievenpiper, University of Toronto, Sept. 2018.

A cause-and-effect relationship can only be demonstrated in well-controlled, randomized studies, which was done recently. In an extensive publication by Murphy and colleagues (21) of the Center for Chemical Regulation and Food Safety, in the USA, entitled "100% fruit juice and measurements of glucose regulation and insulin sensitivity: a systematic review and meta-analysis of randomized controlled trials" the authors concluded that the available randomized and well-controlled studies show that repeated intake of 100% fruit juice has no adverse effect on risk factors for type 2 diabetes. These findings confirm the observations from the above mentioned well-conducted observational studies that consumption of 100% fruit juice is neutral with respect to blood glucose management and therefore also the risk for type 2 diabetes.

Very recently Kahn et al (22) presented the outcomes from a meta-analysis on the effects of sugar sources on the risk of diabetes. Data from 84 prospective cohort studies, lasting ≥ 1 year with data from 3,899,203 individuals were evaluated. This very extensive work confirmed an effect of SSBs and fruit drinks with added sugars on increased diabetes risks. However, in this analysis, 100% fruit juice had no effect on diabetes risks.

Using a metabolomics analysis approach, Rangel Huerta et al (23, 24) showed that consumption of polyphenols contained in orange juice suppresses oxidative stress and inflammation in overweight and obese people. In this respect, it should be noted that 100% juice as commercially available is almost always pasteurized for reasons of food safety and shelf life. It has been shown that the pasteurization process increases the bio-accessibility and bioavailability of antioxidants - polyphenols. In that respect, pasteurized 100% juice is not subordinate to freshly squeezed juice (25).



Jenkins et al. Am J Clin Nutr 1981;34:362.

Fig 2: Blood glucose response values after consuming orange or 100% orange juice, compared to an equivalent amount of available sugars ingested as glucose control drink. The effect of orange fruit and the 100% juice is comparable. Both responses are significantly lower than those of glucose ⇒glycemic index (GI) values of some selected

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fruits and 100% juices derived therefrom is low (see table 1). "Reproduced with permission from Prof Dr D. Jenkins, University of Toronto, Sept. 2018.

Fruit	GI fruit raw [a]	GI fruit raw [b]	GI 100% juice [a]	GI 100% juice [b]
Apple	39	28-44	37-44	28-44
Orange	33-40	31-51	46-54	31-51
Sucrose	-	-	65±4*	72±8*

*Table 1: Glycemic index values as a result of eating fruit or drinking 100% juice. Source: (26): [a] In individuals with normoglycemia, [b] in individuals with impaired glucose tolerance. Values represent the range of mean values of available studies, GI vs. glucose control. * mean of 6 studies*

Penczynski et al. (27) published that higher daily flavonoid intake with fruit, fruit juice and vegetables during adolescence is relevant for the prevention of risk factors of type 2 diabetes in early adulthood. They argue that this has considerable advantages in the long term with regard to insulin sensitivity, fatty liver and chronic subclinical inflammation in the body. The authors state that, in the studies that they evaluated, apples (with peel), red cabbage, strawberries, grapes and orange juice were the most important flavonoid rich sources and almost 50% contributed to the total intake. In line with the above observations, Clemens (28) reported conclusions drawn by the American Food Advisory Committee recommended in 2010, the Australian Dietary Guidelines in 2013, and the Academy of Nutrition and Dietetics Evidence Analysis Library in 2014, that 100% fruit juice is not related to adiposity in children when it is consumed in suitable quantities for age and energy needs (28)

Based on the current insights gained from well-controlled studies and meta-analyzes, it can be concluded that 100% fruit juice fits a healthy diet as part of an overall healthy lifestyle. An important point must be mentioned in the context of the above information. There is no difference in the mono-. di-, and oligosaccharide molecules of the sugars as present in table sugar, syrups, soft drinks, fruit juices and fruits. The digestion, absorption and metabolism of these molecules is, independently of the source, exactly the same. Although 100% fruit juice in relation to soft drinks contains a wide range of micronutrients and bioactive plant compounds, which generally are considered to be beneficial to health, the associated positive effects can be nullified in the case of regular quantitatively excessive consumption leading to a high amount of sugar intake.

It is well established that sugars in solution drive the development of obesity more than the same sugars do as present in solid foods (29, 30). In a recent study by Hägele et al. (31), who recruited 26 healthy adults to participate is a 2 x 2 weeks randomized crossover trial with a 1-week wash-out period in between, participants were asked to consume 20% of their daily energy needs as 100% orange juice, providing a very high average of 1.3 liters + 112g natural

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sugars/day. It was observed that when such an excessive amount of orange juice was consumed between meals, fat mass increased on average by 1kg ($p<0.05$). Surprisingly, when orange juice was consumed with a meal, average fat mass significantly reduced by 2.5kg ($p<0.05$). The latter observation clearly requires further evaluation and study.

Concluding remarks.

According to the information presented here, a 'golden rule' may apply: "100% orange juice, as part of a healthy diet, is a good choice provided that no more juice than as present in 1- max 3 fruits is present, is consumed at a time. In the case of orange juice, this corresponds to one champagne glass of juice (100-150ml). In this respect 100% fruit juice should be perceived as a nutritional drink that can be consumed with a meal and not as a thirst quencher.

Abbreviations used:
CVD- cardiovascular disease
SSBs -sugar sweetened beverages
ASs -added sugars
NOSs -naturally occurring sugars
BMI-Body Mass Index
GI-glycemic index

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