EFFECTS OF DIFFERENT SUGAR SOLUTIONS ON BODY WEIGHT, RETROPERITONEAL FAT MASS, SERUM AND LIVER TRIGLYCERIDE CONTENT AND KIDNEY FUNCTION IN SPRAGUE-DAWLEY RATS

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Introduction:

The replacement of sucrose with high-fructose corn syrup (HFCS, blend of 50-55% fructose and 42-45% glucose) as a sweetener in the U.S. coincided with increase of the prevalence of obesity and chronic kidney disease (figures 1-3). This raised suspicions of the contribution of HFCS to both pandemics [1]. A ~10% higher content of fructose in most HFCS, as compared to sucrose, was suspected as a potential explanation, given that diets excessively rich in fructose (60% of daily caloric intake) were found to cause metabolic syndrome or induce tubulointerstitial kidney injury in animals [3].

It is not clear whether a long-term intake of smaller quantities of fructose, corresponding to ingestion in general population, can exert a negative metabolic effect, nor if sucrose and HFCS differ in such action.

We aimed to compare long-term effects of sucrose vs. blend of fructose and glucose in proportions corresponding to HFCS on body weight, visceral fat mass, liver triglyceride content, and basic metabolic and kidney function parameters in Sprague-Dawley rats, with daily fructose intake close to that in general population.

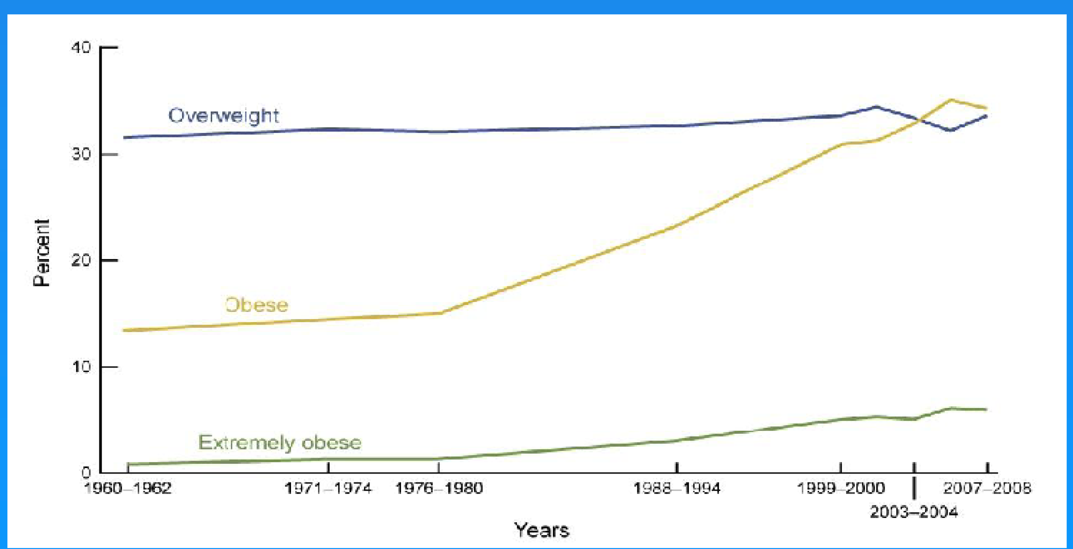

Figure 1. Overweight and obesity in United States between 1960 and 2008 (CDC/NCHS, Health, United States, 2009).

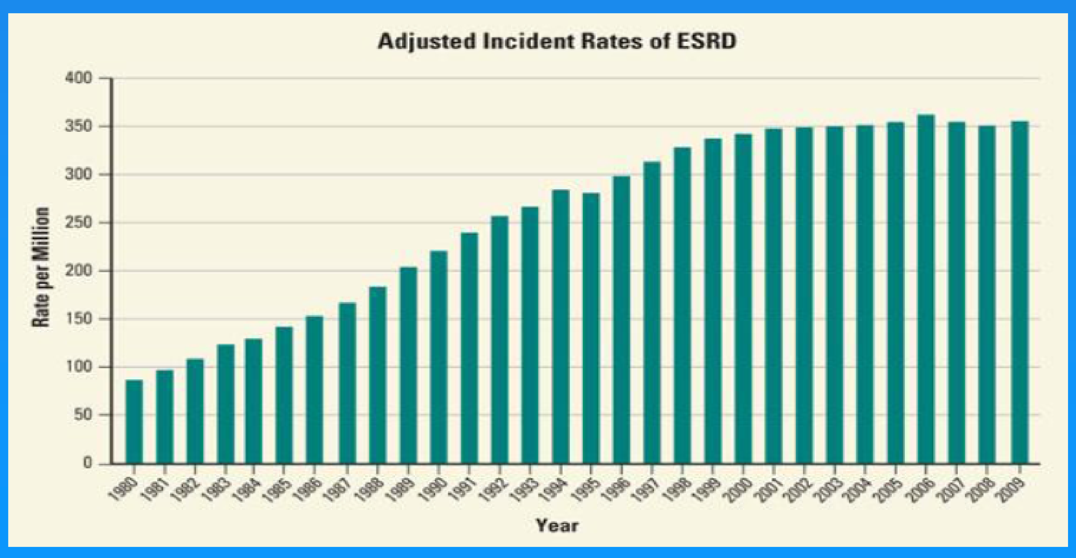

Figure 2. Incidence of end-stage renal disease in United States between 1980 and 2009 (NKDEP/NIDDK, NIH, USA).

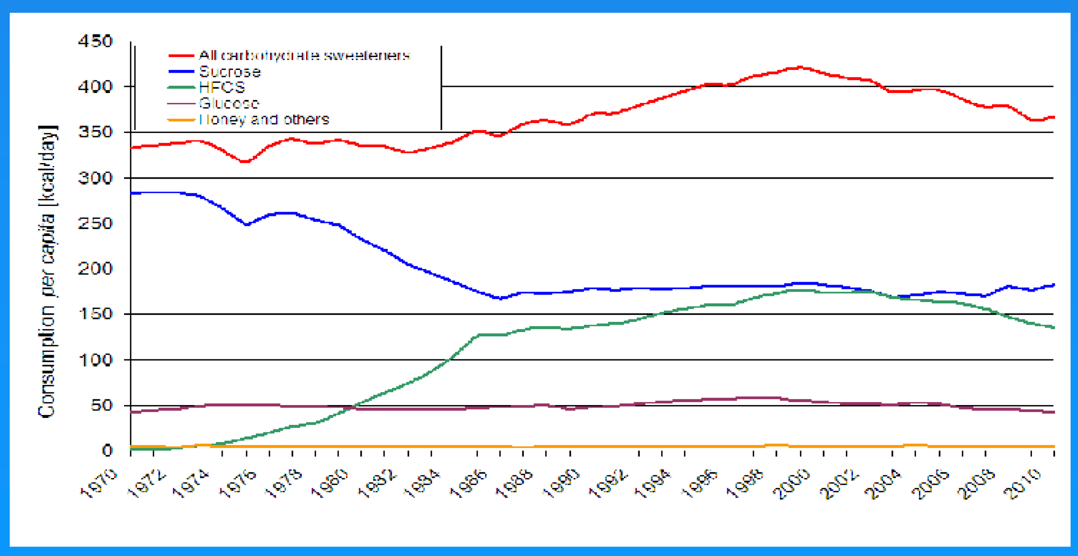

Figure 3. Ingestion of carbohydrate sweeteners in United States between 1970 and 2011 (USDA/ERS, 2012).

Methods:

36 6-week old male Sprague-Dawley rats were housed in individual cages and assigned to 34 weeks of unlimited access to 5% solution of sucrose (12 rats, Sucrose group) or 5% solution of a blend of 55% fructose and 45% glucose (12 rats, 55F/45G) or tap water (12 rats, Water), and standard chow containing ~60% carbohydrates with no fructose.

After 34 weeks in these conditions, rats were placed in metabolic cages for 24 hours with food deprivation, access to water only and urine being collected. Subsequently blood was taken from orbital plexus and the animals were sacrificed. *Post mortem* retroperitoneal fat pads were excised and weighed and liver samples were obtained.

Fluid, chow, fructose, and total energy intakes, weight changes, liver and retroperitoneal fat masses, liver triglyceride content, serum glucose, uric acid, cholesterol, and triglyceride concentrations, as well as diuresis, creatinine clearance and urine protein/creatinine ratio were compared between the groups.

Results:

Rats consuming sugar solutions covered ~10% of their daily caloric intake with fructose, which corresponds with general population intake of fructose [4].

Reduction of chow intake compensatory to caloric intake from fluids was similar in both groups provided with sweetened fluids (table).

Body weight gain, total energy intake, serum cholesterol, triglyceride and glucose levels, liver triglyceride content, as well as urine volume, glomerular filtration or proteinuria did not differ between study groups.

On the other hand, liver mass was ~10% increased and retroperitoneal fat mass was ~40% greater in rats consuming either of the sugar solutions than in animals given water.

	Sucrose n=12	55F/45G n=12	Water n=12
Baseline body weight [g]	188±15	192±15	195±13
Final body weight [g]	587±68	602±43	579±45
Fluid intake/day [ml]	80.3±21.7*	74.9±18.2*	46.4±8.9
Chow intake/day [g]	19.2±3.2*	18.0±2.9*	22.8±2.9
Total energy intake/day [kJ]	295.5±37.3	274.2±33.7	273.7±34.6
Energy from fructose/day [kJ]	30.9±8.3*	31.7±7.7*	0
Serum total cholesterol [mmol/l]	1.36±0.2	1.21±0.28	1.19±0.31
Serum triglycerides [mmol/l]	1.02±0.48	0.78±0.41	0.75±0.22
Serum glucose [mmol/l]	6.29±0.88	6.21±0.89	6.22±0.83
Serum uric acid [µmol/l]	45.6±15.5	45.4±19.3	37.9±5.5
Liver mass [g]	17.6±1.9*	17.5±2.0**	16.0±1.6
Liver triglyceride content [mg/g]	3.31±1.43	3.40±1.27	3.27±1.39
Retroperitoneal fat mass [g]	11.4±3.3**	11.4±1.6*	8.1±2.8
and retroperitoneal fat mass/body weight [%]	2.06±0.57*	1.91±0.34*	1.42±0.45
Left kidney mass [g]	1.37±0.14	1.43±0.11	1.44±0.11
Urine volume [ml]	13.6±3.6	10.8±3.3	11.5±5.1
Serum creatinine [µmol/l]	30.8±4.9	30.3±3.8	27.8±4.9
Creatinine clearance [ml/min/kg bw]	3.35±1.84	3.24±1.02	3.93±2.00
Urine protein/creatinine ratio [mg/mg]	3.01±3.92	1.12±0.91	1.97±1.93

**P<0.05 vs. Water, **P=0.05 vs. Water; Sucrose vs. 55F/45G: all P>0.1; Mann-Whitney U test*

Conclusions:

1) **Unrestricted intakes of 5% solutions of sucrose or a blend of fructose and glucose resembling HFCS for 34 weeks do not increase body weight, fasting serum glucose or lipids, serum uric acid levels or liver triglyceride content, nor do they affect kidney function in Sprague-Dawley rats.**
2) **On the other hand, their consumption leads alike to increased liver mass and adipose tissue accumulation in the retroperitoneal depot, indicative of an increase of visceral adiposity with fructose consumption from either of the most common dietary sources.**

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