Insulin resistance associated with the intake of fructose-containing beverages among adolescents

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Background

Hand-shaken sugar-sweetened beverages (SSB) produced from bubble tea related shops are concentrated in locations in areas within a short walking distance from the residences and schools, that expose adolescents to a direct surrounding with high and easy accessibility of Taiwanese style fructose-containing beverages (FCB). Insulin resistance (IR) is a metabolic disorder that has been linked to diabetogenic process. Studies have found that subjects who have IR in the youth are at an elevated risk of developing type 2 diabetes in adult life.

Objective

To evaluate the effect of FCB consumption on pediatric IR, we assessed data from 1454 representative adolescents who were multistage-sampled from 36 junior high schools in Taiwan.

Methods

We evaluated data from 1454 representative adolescents who were multistage-sampled from 36 junior high schools in Taiwan. Data assessments included demographic factors, dietary, physical activity, anthropometric and clinical measures. We used two groups of surrogate markers to estimate insulin resistance, beta cell function and insulin sensitivity. The first group of indices included the original homeostatic model assessment (HOMA1) of insulin resistance (HOMA1-IR), the second group of indices was derived from an updated non-linear HOMA model (HOMA2). Survey-data modules were applied in all data, and multivariate regression and logistic models were used to controlling for potential confounders.

Results

Higher SSB consumption was associated with higher levels of body mass index (BMI), uric acid, original homeostasis model assessment of insulin resistance (HOMA1-IR), updated HOMA nonlinear computer model (HOMA2-IR), even participants with cardiovascular disease, hypertension or diabetes were excluded. Adjusted for BMI and covariates, heavy FCB drinkers had a 0.41and 0.23 higher level of HOMA1-IR and HOMA2-IR, respectively, than non-drinkers.

Conclusions

While type 2 diabetes does not become clinically apparent until the adulthood, our findings highlight the effect of high FCB consumption on IR among adolescents.

Table 1. Adjusted odds ratios (aOR) of body mass index, body adiposity index and hyperuricemia associated with sugar sweetened beverages intake among adolescents

Factors	Subject, no.	Body mass index (kg/m^2)[a]		Body adiposity index (%)[b]		Hyperuricemia
		OW vs. UNW	OB vs. UNW	OW vs. UNW	OB vs. UNW	Yes vs. No
		aOR[c] (95% CI)	aOR[c] (95% CI)	aOR[c] (95% CI)	aOR[c] (95% CI)	aOR[c] (95% CI)
Non-intake	154	1.0	1.0	1.0	1.0	1.0
HFCS-containing HSS drink						
Slight-to-half	548	2.0 (0.9-4.6)	1.6 (0.8-3.2)	1.0 (0.4-2.1)	2.6* (1.0-6.5)	1.3 (0.8-2.2)
Heavy	247	2.1 (0.9-5.2)	1.9 (0.9-4.0)	0.7 (0.3-1.5)	2.4 (0.9-6.4)	**2.0*** (1.2-3.4)
BSC drink	505	3.1* (1.4-7.0)	**2.4*** (1.1-4.9)	1.7 (0.8-3.4)	**4.2*** (1.7-10.3)	**1.9*** (1.2-3.1)

Abbreviations: UNW, under/normal weight; OW, overweight; OB, obesity; HSS, hand-shaken sugar-sweetened; HFCS, high-fructose corn syrup; BSC, bottled sugar-containing. *P < 0.05.
[a]Asian BMI criteria: UNW, BMI≤23.9; OW, BMI=24–26.9; OB, BMI≥27.
[b]BAI criteria for aged 20-40 years: UNW, BAI≤21.9; OW, BAI=22–27; OB, BAI>27 for men, BAI≤34.9; OW, BAI=35–40; OB, BAI>40 for women.
[c]Model was adjusted for age, gender, ethnicity, physical activity and total calories.

Table 2. The multivariate-adjusted difference in body mass index and serum uric acid associated with the type of sugar sweetened beverage (SSB) consumed among adolescents in southern Taiwan

Factors	Model I[a]	Adj. BMI[b]	Effect[c]	Adj. BAI[b]	Effect[c]	Adj. SUA[b]	Effect[c]
	aDiff. (95% CI)	aDiff. (95% CI)	explained	aDiff. (95% CI)	explained	aDiff. (95% CI)	explained
Non-intake	**Ref.**	**Ref.**		**Ref.**		**Ref.**	
HOMA1-IR							
Beverage type							
Slight-to-half	**0.31* (0.05, 0.57)**	**0.28* (0.02, 0.54)**	9.6%	**0.27* (0.01, 0.53)**	13.3%	**0.27* (0.02, 0.52)**	12.5%
HSS							
Heavy HSS	**0.45* (0.08, 0.82)**	**0.41* (0.06, 0.75)**	10.4%	**0.41* (0.05, 0.77)**	9.0%	**0.37* (0.01, 0.73)**	18.6%
BSC	0.18 (-0.06, 0.43)	0.06 (-0.20, 0.32)	-	0.07 (-0.19, 0.33)	-	0.13 (-0.12, 0.37)	-
HOMA2-IR							
Beverage type							
Slight-to-half	**0.19* (0.05, 0.32)**	**0.17* (0.03, 0.31)**	8.5%	**0.16* (0.03, 0.30)**	11.7%	**0.17* (0.03, 0.30)**	10.5%
HSS							
Heavy HSS	**0.26* (0.07, 0.45)**	**0.23* (0.05, 0.41)**	9.6%	**0.24* (0.05, 0.42)**	8.2%	**0.22* (0.03, 0.40)**	16.4%
BSC	0.12 (-0.02, 0.26)	0.05 (-0.09, 0.20)	-	0.06 (-0.08, 0.20)	-	0.09 (-0.05, 0.22)	-

Abbreviations: BMI, body mass index; BAI, body adiposity index; SUA, serum uric acid; HFCS, high-fructose corn syrups; HSS, hand-shaken sugar-sweetened; BSC, bottled sugar-containing; HOMA1-IR, original homeostasis model assessment of insulin resistance; HOMA2-IR, updated HOMA nonlinear computer model of insulin resistance;* P < 0.05.
[a]Model was adjusted for age, gender, ethnicity, physical activity and total calories.
[b]Model I was additionally adjusted for BMI, BAI and SUA, respectively.
[c]Effects explained by the covariate additionally adjusted for.

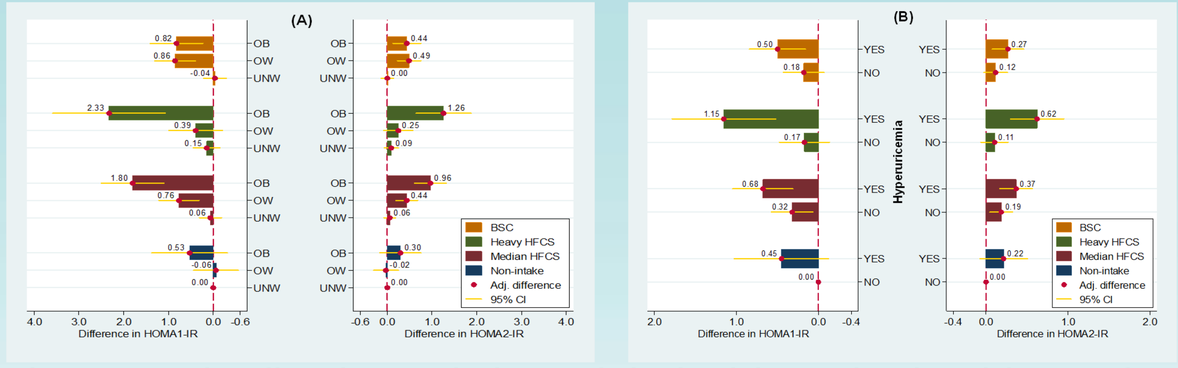

Figure 1. Interplay effects between body mass index (BMI), hyperuricemia and the type of sugar-sweetened beverage (SSB) intake on the difference in insulin resistance.