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Biomarker-predicted sugars intake compared with self-reported measures in US Hispanics/Latinos: results from the HCHS/SOL SOLNAS study

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Abstract

Objective: Measurement error in self-reported total sugars intake may obscure associations between sugars consumption and health outcomes, and the sum of 24 h urinary sucrose and fructose may serve as a predictive biomarker of total sugars intake.
Design: The Study of Latinos: Nutrition & Physical Activity Assessment Study (SOLNAS) was an ancillary study to the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) cohort. Doubly labelled water and 24 h urinary sucrose and fructose were used as biomarkers of energy and sugars intake, respectively. Participants' diets were assessed by up to three 24 h recalls (88 % had two or more recalls). Procedures were repeated approximately 6 months after the initial visit among a subset of ninety-six participants.
Setting: Four centres (Bronx, NY; Chicago, IL; Miami, FL; San Diego, CA) across the USA.
Subjects: Men and women (n 477) aged 18–74 years.
Results: The geometric mean of total sugars was 167·5 (95 % CI 154·4, 181·7) g/d for the biomarker-predicted and 90·6 (95 % CI 87·6, 93·6) g/d for the self-reported total sugars intake. Self-reported total sugars intake was not correlated with biomarker-predicted sugars intake ($r=-0{\cdot}06$, $P=0{\cdot}20$, n 450). Among the reliability sample (n 90), the reproducibility coefficient was 0·59 for biomarker-predicted and 0·20 for self-reported total sugars intake.
Conclusions: Possible explanations for the lack of association between biomarker-predicted and self-reported sugars intake include measurement error in self-reported diet, high intra-individual variability in sugars intake, and/or urinary sucrose and fructose may not be a suitable proxy for total sugars intake in this study population.

Keywords
Sugars
Doubly labelled water
Self-report
Urinary sucrose and fructose biomarkers
Hispanics/Latinos

According to the American Heart Association, excessive dietary sugars intake, especially in the form of fructose consumption, may contribute to obesity, insulin resistance, type 2 diabetes, hypertension and dyslipidaemia[1]. Possible pathways potentially explaining the role of dietary sugars in increasing cardiometabolic risk include: (i) excess energy

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intake; and/or (ii) high dietary glycaemic load leading to inflammation, insulin resistance and impaired β-cell function[1,2]. US Hispanics/Latinos are 25 (95 % CI 13, 38) % more likely to report sugar-sweetened beverage consumption than non-Hispanic/Latino adults according to data from the National Health and Nutrition Examination Survey 2007–2008[3]. Type 2 diabetes is highly prevalent among Hispanics/Latinos in the USA, with wide variability based on Hispanic/Latino background, ranging from 10·2 % in South Americans to 18·3 % in Mexicans ($P < 0·0001$)[4].

Measurement error in self-reported intake has impeded progress in definitively addressing diet–disease hypotheses[5–9]. Identified strategies for mitigating measurement error include statistical approaches that combine two dietary assessment approaches (e.g. FFQ and 24 h recall (24HR) or biomarker with self-reported diet data)[10,11], integration of validated biomarkers into epidemiological studies, and the development and validation of new biomarkers that characterize dietary components[12,13]. Nutrient biomarkers have been classified as recovery, concentration, predictive or replacement[14], depending upon whether the biomarker reflects an absolute level of intake or is correlated with dietary intake (i.e. recovery *v.* concentration), the degree to which the biomarker is recovered and quantifiable (i.e. predictive)[15] or is used as a surrogate measure of intake for nutrients difficult to assess or with no food composition data available (i.e. replacement).

Methodological approaches for incorporating biomarkers within epidemiological studies have been developed[10,11,16] and applications of these approaches have strengthened associations in diet–disease analyses[17–20]. With combined biomarker and self-reported dietary data, the sample size requirement for estimating diet–disease associations may be reduced by 20–50 % compared with self-reported intake alone[11]. A predictive biomarker for total sugars intake (i.e. sum of fructose and sucrose in 24 h urine) developed in two controlled feeding studies in the UK showed that the sum of urinary sucrose and fructose in 24 h urine was significantly correlated with total sugars ($r = 0·841$, $P < 0·001$) and sucrose intake ($r = 0·773$, $P = 0·002$)[15]. This biomarker has been recently integrated into two US-based biomarker studies with free-living individuals as a reference instrument against FFQ-, 24HR- and food record-based sugars intake[21,22]. The objective of the present study was to compare the consumption of sugars estimated from self-report with values derived from a biomarker of sugars intake nested within a large observational cohort study of Hispanic/Latino adults living in the USA.

Methods

Study description

The Study of Latinos: Nutrition & Physical Activity Assessment Study (SOLNAS), an ancillary study of the Hispanic Community Health Study/Study of Latinos (HCHS/SOL), included Hispanic/Latino men and women aged 18 to 74 years at HCHS/SOL baseline who were recruited from four centres (Bronx, NY; Chicago, IL; Miami, FL; San Diego, CA) across the USA, as previously described[23–25]. After excluding SOLNAS participants having incomplete (<500 ml/d) or missing urine samples (*n* 26 for the primary study and *n* 6 for the reliability study), the analytic sample was 450 for the primary sample and ninety for the reliability sample. Dietary recalls were excluded at each time point if reported daily energy intake was <2510 or >12 552 kJ (<600 or >3000 kcal) for women or <3347 or >16 736 kJ (<800 or >4000 kcal) for men (Fig. 1)[26].

Energy expenditure and self-reported physical activity assessment

Energy expenditure was measured using a doubly labelled water (DLW) protocol[27]. Following the collection of a baseline urine sample, participants ingested a DLW mixture that provided 1·38 g of 10 at% ^{18}O-labelled water and 0·086 g of 99·9 at% ^{2}H-labelled water per kilogram body weight and provided in-clinic spot urines at 3 and 4 h[28]. Participants aged ≥60 years provided a blood sample 3 h post-isotope to allow adjustment for age-related post-void urine retention. An additional post-dose sample was collected on day 12 of the DLW protocol. Self-reported

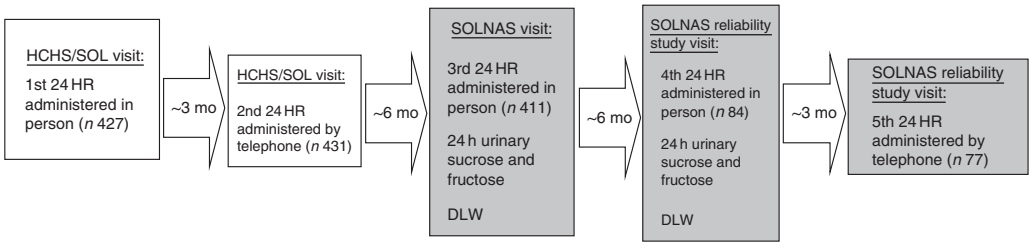

Fig. 1 Study flow diagram: estimating self-reported dietary intake using the National Cancer Institute (NCI) method and objective dietary intake using biomarkers of energy and sugars intake within the Study of Latinos: Nutrition & Physical Activity Assessment Study (SOLNAS), an ancillary study of the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) cohort. At each time point, 24 h recalls (24HR) were excluded if energy intake was <2510 or >12 552 kJ (<600 or >3000 kcal) for women or <3347 or >16 736 kJ (<800 or >4000 kcal) for men. Combining recalls using the NCI method, the analytic sample size was 450 for the primary study and ninety for the reliability study. For deriving usual intake, 24HR from the entire HCHS/SOL were used (*n* 15 622 for visit 1 and *n* 14 709 for visit 2). *n*, sample size; mo, months; DLW, doubly labelled water

physical activity was assessed by the Global Physical Activity Questionnaire that was developed by the WHO to quantify time spent in moderate and vigorous levels of physical activity at work, travel and leisure time[29,30]. Twenty per cent of the participants (*n* 96) repeated the protocol to obtain reliability measures.

Self-reported sugars intake assessment

Self-reported sugars intake was estimated using the National Cancer Institute (NCI) method[31], using all available data to estimate usual dietary intake by combining up to five 24HR recalls (Fig. 1). In-person 24HR were conducted at the HCHS/SOL baseline, SOLNAS baseline and the SOLNAS reliability study visit (see online supplementary material, Supplemental Table 1). Interviews were conducted in Spanish or English depending on the participant's preference with the Nutrition Data System for Research (NDS-R) software (version 11) developed by the Nutrition Coordinating Center at the University of Minnesota, which uses the multiple-pass method and has a database with >18 000 foods. As described by Tooze *et al.*[32], the NCI method for estimating usual intake involved two steps. The first step (NCI MIXTRAN macro) specifies the consumption-day amount using linear regression on a transformed scale, with a person-specific effect adjusted for sex, age, Hispanic/Latino background, field centre, weekend (including Friday), self-reported intake amount (more, same or less than usual amount) and sequence (i.e. Fig. 1, first through fifth recall). The second step (NCI INDIVINT macro) calculates the individual's predicted usual intake using parameter estimates from the first step.

Biomarker-predicted energy assessment

The urine and plasma samples collected within the DLW protocol from SOLNAS participants were analysed by gas-isotope-ratio MS to assess energy expenditure[33]. The isotopic data were converted to energy expenditure values based on an energy equivalent of 1 litre of CO_2 to be 3·815/RQ + 1·2321, where RQ is the respiratory quotient equal to 0·86, a standard among populations consuming a Western diet which is based on a high-fat diet[25,34].

Biomarker-predicted sugars assessment

At SOLNAS baseline, participants collected one 24 h urine sample that was analysed for sucrose and fructose. Urinary sucrose and fructose were measured by LC-MS at the University of Hawaii Cancer Center[35]. Urine samples (20 µl) mixed with internal standards were dried using N_2 and reconstituted in 100 µl MeOH. The redissolved sample was centrifuged and the supernatant (10 µl) was injected into the LC-MS system (model Accela ultra HPLC coupled to a TSQ Quantum Ultra tandem mass spectrometer with Xcalibur™ software; ThermoFisher, San Jose, CA, USA). Chromatographic separations were performed on a ZIC®-HILIC column (100 mm × 2·1 mm, 3 µm; Merck KGaA, Darmstadt, Germany) by gradient elution using 0·1 % (v/v) formic acid in MeCN and 0·1 % (v/v) formic acid in H_2O at a flow rate of 0·3 ml/min. Masses were continuously monitored by atmospheric-pressure chemical ionization in negative mode and selected ion monitoring by extracting the respective accurate mass-to-charge (m/z) ratios.

Among a 10 % blinded quality control sample (collected about once per month from among SOLNAS 24 h urine samples; *n* 50), the CV were 11·7 % for fructose and 8·0 % for sucrose. Per an internal laboratory quality control (*n* 11), intra-day CV were 4·6 % for fructose and 5·8 % for sucrose, and inter-day CV were 10·5 % for both fructose and sucrose.

We used the calibration equation (1) below for total sugars biomarker, previously developed based on data from a feeding study[15,21], to calibrate the biomarker (i.e. sum of 24 h urine sucrose and fructose) and to derive biomarker-predicted sugars (BPS) intake in SOLNAS participants:

$$PM_{ij} = M_{ij} - 1{\cdot}67 - 0{\cdot}02 \times S_i + 0{\cdot}71 \times A_i, \quad (1)$$

where:

- PM_{ij} = log-transformed calibrated biomarker, i.e. BPS intake, for individual i on day j;
- M_{ij} = log-transformed (sum of 24 h urine fructose and sucrose) for individual i on day j;
- S_i = sex of individual i (0 for men, 1 for women); and
- A_i = log-transformed age of individual i.

Statistical analysis

Both self-reported sugars intake and BPS intake were log-transformed to improve normality. Geometric means and 95 % CI were computed for self-reported sugars and BPS intakes, overall and by selected participant characteristics. Participant characteristics (mean and SD for continuous variables; *n* and % for categorical variables) were summarized by quartile of BPS intake. We assessed the correlations of BPS intake (g/d) with self-reported sugars intake (g/d) using Spearman correlation coefficients. Among the reliability participants, Spearman correlations were calculated to assess the relationship between repeated measures of self-reported and BPS intake.

To examine the sensitivity of the results to the analytic approaches used, results were stratified by accuracy of reporting status, with 'concordance' defined as self-reported energy intake within 25 % of energy expenditure estimated by DLW. Analyses were repeated using the 'raw' sum of 24 h urine fructose and sucrose (i.e. uncalibrated biomarker), rather than using BPS (i.e. calibrated biomarkers), as a measure of objective sugars intake. Furthermore, BPS was correlated to self-reported estimates of total sugars intake from a single 24HR recall which corresponded to the time point closest to the urine collection (e.g. 24HR administered within 7 d of 24 h urine collection), rather than using the NCI method

to estimate usual intake, as the measure of sugars intake. Statistical analyses were conducted using the statistical software package SAS version 9.3.

Results

Overall, geometric mean self-reported total sugars intake was 90·6 (95 % CI 87·6, 93·6) g/d *v.* 167·5 (95 % CI 154·4, 181·7) g/d for biomarker-predicted total sugars intake (Table 1). Whereas self-reported total sugars intake was not associated with participant characteristics, BPS intake was significantly associated with age and ethnicity (Table 2). There was a non-significant trend for a higher proportion of obese individuals and those with lower education level to be in the highest BPS quartile. BPS intake was also higher among older participants and Puerto Ricans. Self-reported total sugars intake was not correlated with BPS ($r = -0{\cdot}06$, $P = 0{\cdot}20$).

The self-reported total sugars intake and BPS intake were not related, irrespective of whether energy expenditure estimated by DLW was within 25 % of self-reported total energy intake ($P > 0{\cdot}05$; Table 3). Usual energy intake was correlated with energy expenditure measured with the DLW method, and it was more highly correlated among true reporters compared with participants who were not classified as concordant reporters ($r = 0{\cdot}79$ *v.* $r = 0{\cdot}54$, $P < 0{\cdot}0001$). Among the participants in the 20 % reliability sub-samples who repeated the entire protocol about 6 months after the SOLNAS baseline visit, the repeated measures of BPS intake at baseline and 6 months were more highly correlated than repeated self-reported total sugars intake ($r = 0{\cdot}59$ *v.* $r = 0{\cdot}20$; for gender-specific reliability coefficients see Fig. 2).

Sensitivity analyses also demonstrated the lack of an association between urinary fructose and sucrose and self-reported total sugars intake. Among the primary study participants, the correlation between the 'raw'/uncalibrated sum of 24HR urinary fructose and sucrose and NCI-based sugars intake was $r = 0{\cdot}03$ ($P = 0{\cdot}58$) and the agreement between quartiles of the raw sum and BPS was high ($\kappa = 0{\cdot}72$, $P < 0{\cdot}0001$; see online supplementary material, Supplemental Table 2). Similarly, the correlation between BPS and a single 24HR corresponding to the time point closest to the urine collection as the measure of self-reported total sugars intake, rather than using the NCI method to estimate usual intake, was $r = 0{\cdot}02$ ($P = 0{\cdot}70$). Within the reliability study, the correlation between BPS and a single 24HR corresponding to the time point closest to the urine collection was $r = 0{\cdot}36$ ($P < 0{\cdot}0001$); the association was stronger in men ($r = 0{\cdot}63$, $P < 0{\cdot}001$) than in women ($r = 0{\cdot}27$, $P = 0{\cdot}04$; Supplemental Table 3).

Table 1 Geometric mean (95 % CI) of self-reported total sugars and biomarker-predicted sugars intake (*n* 450); Study of Latinos: Nutrition & Physical Activity Assessment Study (SOLNAS)

		Self-reported sugars intake (g/d)*		Biomarker-predicted sugars intake (g/d)*	
	n	Mean	95 % CI	Mean	95 % CI
Overall	450	90·6	87·6, 93·6	167·5	154·4, 181·7
Age (years)					
18–44	172	95·2	90·4, 100·3	116·2	101·5, 133·0
45–64	252	88·4	84·5, 92·5	205·6	186·6, 226·6
65+	26	82·0	72·0, 93·4	257·1	183·9, 359·3
Sex					
Women	276	83·5	80·5, 86·6	157·6	142·8, 174·0
Men	174	103·0	97·0, 109·2	184·3	160·0, 212·3
Language of interview					
English	105	99·1	92·4, 106·3	155·3	129·4, 186·3
Spanish	345	88·1	84·9, 91·4	171·3	156·4, 187·7
Weight status					
Underweight (<18·5 kg/m^2)	4	80·8	44·7, 146·1	203·0	83·8, 492·0
Normal (18·5–24·9 kg/m^2)	85	101·9	95·2, 109·1	135·4	112·4, 163·1
Overweight (25·0–29·9 kg/m^2)	180	87·8	83·6, 92·3	171·2	151·9, 193·0
Obese (≥30·0 kg/m^2)	181	88·5	83·7, 93·7	180·2	157·0, 207·0
Hispanic/Latino background					
Central American	50	87·6	79·0, 97·2	170·6	129·9, 224·1
Cuban	65	82·4	75·6, 89·8	186·1	152·7, 226·8
Dominican	47	70·9	64·5, 78·0	138·2	97·6, 195·8
Mexican	135	98·8	93·8, 104·1	153·3	133·1, 176·7
Puerto Rican	115	94·0	87·6, 100·9	198·9	170·1, 232·6
South American	38	98·3	88·3, 109·5	140·3	114·5, 171·9
Income					
Low income (<$US 30 000/year)	299	91·3	87·7, 95·1	172·8	156·5, 190·7
High income (≥$US 30 000/year)	119	90·7	85·0, 96·8	157·7	133·9, 185·6
Missing	32	83·0	73·3, 94·1	156·4	112·2, 218·0
Education					
Less than high school	143	89·8	84·7, 95·2	199·1	170·8, 232·1
High school equivalent	112	93·5	87·1, 100·5	163·6	139·5, 191·9
Greater than high school	195	89·4	85·2, 93·9	149·4	132·7, 168·3

Table 2 Characteristics of participants by quartile of biomarker-predicted total sugars intake (*n* 450); Study of Latinos: Nutrition & Physical Activity Assessment Study (SOLNAS)

	Q1 (*n* 113)		Q2 (*n* 112)		Q3 (*n* 112)		Q4 (*n* 112)		
Characteristic	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*P* value
Biomarker-predicted total sugars intake (g/d), range	6·5–104·5		104·7–168·3		169·4–276·0		277·8–2921·2		
Self-reported intake, NCI method									
Total sugars intake (g/d)	98	32	96	34	97	39	95	35	0·9
Energy intake (kJ/d)	8163	1992	7971	2050	7883	2138	7816	2059	0·41
Energy intake (kcal/d)	1951	476	1905	490	1884	511	1868	492	0·41
Energy expenditure by DLW (kJ/d)	9908	2013	9908	2192	10 205	2109	10 535	2276	0·10
Energy expenditure by DLW (kcal/d)	2368	481	2368	524	2439	504	2518	544	0·10
Age (years)	39	13	46	12	48	12	52	11	<0·0001
	n	%	*n*	%	*n*	%	*n*	%	
Gender									0·54
Female	74	65·5	71	63·4	67	59·8	64	56·6	
Male	39	34·5	41	36·6	45	40·2	49	43·4	
Weight status									0·41
Underweight (<18·5 kg/m^2)	0	0·0	1	0·9	2	1·8	1	0·9	
Normal (18·5–24·9 kg/m^2)	28	24·8	25	22·3	16	14·3	16	14·2	
Overweight (25·0–29·9 kg/m^2)	43	38·1	45	40·2	48	42·9	44	38·9	
Obese (≥30·0 kg/m^2)	42	37·2	41	36·6	46	41·1	52	46·0	
Hispanic/Latino background									0·04
Central American	16	14·2	10	8·9	10	8·9	11	9·7	
Cuban	15	13·3	11	9·8	11	9·8	13	11·5	
Dominican	15	13·3	10	8·9	18	16·1	22	19·5	
Mexican	37	32·7	39	34·8	34	30·4	25	22·1	
Puerto Rican	21	18·6	26	23·2	29	25·9	39	34·5	
South American	9	8·0	16	14·3	10	8·9	3	2·7	
Income									0·36
Low income (<$US 30 000/year)	74	65·5	65	58·0	81	72·3	79	69·9	
High income (≥$US 30 000/year)	29	25·7	38	33·9	25	22·3	27	23·9	
Missing	10	8·9	9	8·0	6	5·4	7	6·2	
Educational level									0·56
Less than high school	32	28·3	31	27·7	37	33·0	43	38·1	
High school equivalent	26	23·0	31	27·7	30	26·8	25	22·1	
Greater than high school	55	48·7	50	44·6	45	40·2	45	39·8	
Smoking									0·22
Never	79	69·9	66	58·9	65	58·0	58	51·8	
Past	17	15·0	22	19·6	22	19·6	28	25·0	
Current	17	15·0	24	21·4	25	22·3	26	23·2	
Self-reported physical activity* (min/week)	439	684	580	1019	675	993	461	735	0·15

DLW, doubly labelled water.
*Self-reported physical activity is the total amount of time spent doing some form of physical activity for work, transportation, recreation and sedentary behaviour in a week from the modified Global Physical Activity Questionnaire (GPAQ; available at https://www2.cscc.unc.edu/hchs/system/files/forms/UNLICOMMPhysicalPAE02182008.pdf).

Table 3 Spearman correlations between self-reported and biomarker-based intakes of energy and sugars by concordance with doubly labelled water*

Concordance	*n*	Energy intake (kcal/d)	*P* value	Total sugars (g/d)	*P* value
Concordant	234	0·79	<0·0001	0·04	0·59
Discordant	210	0·54	<0·0001	−0·06	0·37

*Concordance = reported energy intake within 25 % of energy intake measured with the doubly labelled water method.

Discussion

Among a sizeable, diverse sample of Hispanics/Latinos, BPS intake was not correlated with self-reported total sugars intake. Whereas BPS was correlated with age and ethnicity, self-reported total sugars intake was unrelated to participant characteristics. Contrary to expectation, there was no significant association between BMI and BPS[36]. Using the sugars biomarker measured in spot urines, the European Prospective Investigation into Cancer and Nutrition–Norfolk reported positive associations between sucrose intake and obesity[37,38] and a randomized, crossover trial in ten normal-weight and nine overweight/obese participants suggested BMI does not affect the

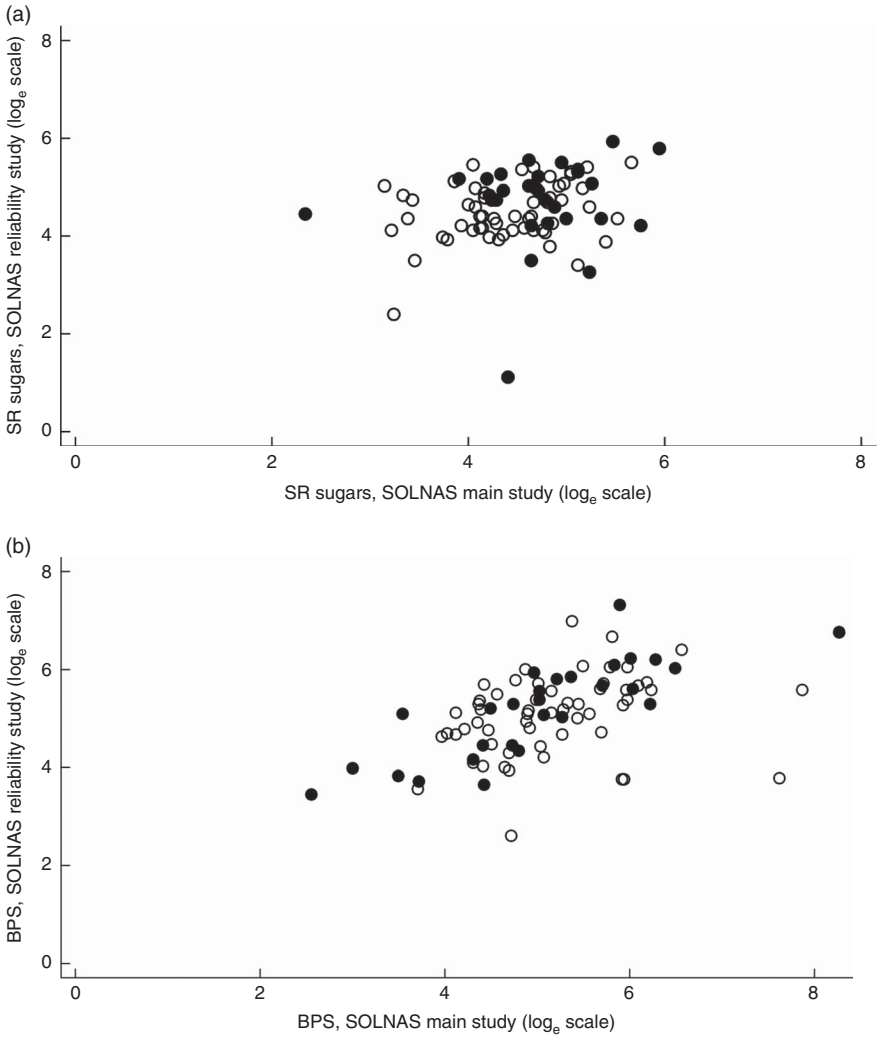

Fig. 2 Correlation of (a) self-reported (SR) total sugars intake and (b) biomarker-predicted sugars (BPS) intake, by sex (○, women; ●, men), between participants in the reliability sub-sample and participants in the main study; Study of Latinos: Nutrition & Physical Activity Assessment Study (SOLNAS). (a) Women (n 58): Spearman's $\rho = 0.21$, $P = 0.11$; men (n 32): Spearman's $\rho = 0.12$, $P = 0.50$. (b) Women (n 57): Spearman's $\rho = 0.42$, $P = 0.001$; men (n 32), Spearman's $\rho = 0.84$, $P < 0.0001$

validity of the biomarker[39]. As this biomarker, so far, has not been validated for use among Hispanics/Latinos, we cannot definitively quantify the measurement error in the self-reported total sugars intake *v.* BPS intake. However, we conducted further analyses to better understand the reasons for the observed low correlations between self-reported and BPS intake. Using the recovery biomarker for energy intake based on DLW data, just over half of the sample (53 %) was categorized as concordant (i.e. self-reported energy intake values were within 25 % of biomarker values), but there was no association between self-reported total sugars and BPS intakes when results were restricted to this subset.

Possible explanations for the lack of any association between BPS and self-reported sugars intake include measurement error in self-reported sugars intake, variability in sugars intake necessitating multiple 24HR recalls and measures of urinary sucrose and fructose to accurately estimate usual intake, and/or the lack of evidence to support the role of urinary sucrose and fructose as a valid proxy for total sugars intake in this study population. Measurement error in the reporting of energy and protein has been well established in several studies comparing self-reported intake with recovery biomarkers[5,10,16]. Other studies have nested the predictive urinary sucrose and fructose biomarker into validation studies to compare self-reported intake and biomarker-predicted intake of total sugars[21]. In the Women's Health Initiative Nutrition and Physical Activity Assessment Study (NPAAS; n 450), self-reported sugars intake was substantially, and roughly equally, misreported whether measured by FFQ, 4 d food record or 24HR recall[21]. Geometric means of BPS in NPAAS and SOLNAS were similar: 173·9 (95 % CI 142·9, 211·6) g/d *v.* 167·5 (95 % CI 154·4, 181·7) g/d, respectively[21]. The biomarker-prediction equation used in ours and each of these validation studies was derived

from a highly controlled feeding study among seven men and six women in the UK aged 23–66 years[15,21,40]. We noted a strong positive association between the BPS and age (Table 1), which may be due to an overcorrection for age at the higher age ranges. In analyses where we did not apply the biomarker-prediction equation and relied on the sum of urinary sucrose and fructose, associations between age and self-reported intake were null. Data from a controlled feeding study including participants representative of the age, race/ethnicity and BMI of this cohort would inform whether the biomarker-prediction equation is generalizable or needs modification based on these or other participant characteristics.

Whereas recovery biomarkers (i.e. DLW and 24 h urinary-N) are unbiased reference instruments that reflect an absolute level of intake, predictive biomarkers, such as 24 h urinary sucrose and fructose, can also be used as reference validation instruments after being calibrated to account for bias in the biomarker, estimable from a feeding study against known intake[15]. We did not observe significant correlations between self-reported sugars intake and sucrose and fructose based on urinary measurements, even when restricting the analysis to individuals who reported energy intake within 25 % of the DLW value. Another possibility for the lack of correlation between self-reported and BPS intake is that high intra-individual variation in sugars intake would necessitate multiple days of measurement in order to estimate usual intake of total sugars. Among the sub-sample of reliability study participants, the reproducibility of self-reported sugars intake was much lower than the reproducibility of the urinary sucrose and fructose biomarkers. Furthermore, the self-reported intake from the 24HR closest to the urine collection and BPS was significant among reliability participants ($r = 0{\cdot}36$, $P < 0{\cdot}001$, n 84). However, restricting the analysis to individuals having 24HR within one week of the urinary sucrose and fructose biomarker measurement did not result in significant correlations with self-reported sugars intake. Possible explanations include that the reliability participants were more accurate reporters of dietary intake and more compliant with the urine collection protocols compared with the rest of the SOLNAS participants. Since the equation for predicting biomarker-based sugars intake was developed based on a small sample of individuals in the UK, we examined correlations between both the 'raw' sum of urinary sucrose and fructose in addition to applying the biomarker-prediction equation, but this did not substantively alter our results.

Strengths of the current study include applying a predictive biomarker that has been validated in controlled feeding studies to an ethnically diverse cohort, representing both genders, of Hispanics/Latinos in the USA, as well as accounting for a wide range of other factors previously demonstrated to be associated with measurement error in self-reported diet intake, such as age and BMI. The substantial sample size allowed conduct of several sensitivity analyses to ascertain whether our findings were influenced by the characterization of self-reported intake (i.e. usual intake per NCI method or restricting to 24HR within one week of the 24 h urine collection time point) and the level of concordance between DLW and self-reported energy intake. Our ability to make inferences about the magnitude of measurement error in self-reported sugars intake using the biomarker in this study population is limited. Highly controlled feeding studies with participants representative of the HCHS/SOL population would better characterize the application of this biomarker among Hispanics/Latinos.

Conclusion

In conclusion, in comparing a predictive biomarker of sugars intake among a diverse sample of Hispanics/Latinos, no significant associations were detected between the self-reported and biomarker-predicted sugars intakes. Clinical studies that allow for the control of factors such as the amount of total sugars intake, the optimal time frame between sugars intake and biomarker measurement, and health are needed to better determine the potential use of urinary sucrose and fructose as a biomarker of total sugars intake.

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Supplementary material

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