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Underreporting of energy intake and associated factors in a Latino population at risk of developing type 2 diabetes

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Abstract

The objective of this study is to examine the extent of underreporting of total caloric intake and associated factors in a low-income, low-literacy, predominantly Caribbean Latino community in Lawrence, Massachusetts. Two hundred fifteen Latinos participated in a diabetes prevention study, with eligibility included a 30% risk of developing diabetes in 7.5 years. Dietary self-reported energy intake (EI) was assessed using three randomly selected days of 24-hour diet recalls. Basal metabolic rate (BMR_{est}) was estimated using the Mifflin-St Jeor equation.

Underreporting was determined by computing a ratio of EI to BMR_{est} , with a ratio of 1.55 expected for sedentary populations. Linear regression analyses were used to identify factors associated with underreporting (EI: BMR_{est} ratio). The population was predominately female (77%), middle-aged [mean =52 years; standard deviation (SD)=11], obese (78% had a BMI 30 kg/m²); low-literate (62% < high school education), unemployed (57% reported no job), married or living with partner (52%), and some had a family history of diabetes (37% had siblings with diabetes). Reported total daily EI was 1540 kcal (SD=599), whereas estimated BMR was 1495.7 kcal/day (SD=245.1). When multiplied by an activity factor (1.20 for sedentariness), expected caloric intake was 1794 (SD=294.0), indicating underreporting by an average of 254 Kcal/day. Mean EI/ BMR_{est} was 1.03 (SD=0.37), and was lower for participants with higher BMI, siblings with diabetes, sedentary lifestyle, and the unemployed. EI underreporting is prevalent in this low-income, low- literacy Caribbean Latino population. Future studies are needed to develop dietary assessment measures that minimize underreporting in this population.

Keywords

diet

INTRODUCTION

Understanding of the relationship between diet and health outcomes requires accurate self-reports of dietary intake. Although misreporting occurs in both directions, underestimation of energy intake (EI) is more prevalent (1). It is well known from large scale studies in non-Hispanic populations that underreporting is pervasive, and is associated with body mass index (BMI) and female gender (2). In addition, several studies have shown that underreporting of EI is associated with low income (3, 4), older age (5–7), higher social desirability (1, 3, 8), and lower educational levels (9). However, few studies have examined issues regarding the accuracy of dietary assessment in the Caribbean Latino population.

Assessment of dietary intake in Caribbean Latinos in the United States presents numerous challenges. Culture, language, education, socioeconomic status, consumption of traditional foods, understanding ingredients, perceptions about food portion sizes, societal pressures regarding body image and ideal body weight, and health consequences of lifestyle choices all present challenges to accurate dietary assessment (10, 11). Most work conducted in dietary assessment of Latino populations (12) has been done with Mexican-Americans, whose cultures are distinct from Caribbean Latinos.

Dietary assessment is prone to errors, regardless of the method of measurement (8, 13, 14). The commonly used methods including 24-hour diet recall interviews (24HR), food frequency questionnaires, and diet diaries are all associated with challenges for accurate assessment. These include participant memory, awareness of intake, portion size estimation, and psychological traits that motivate one or more biases. The magnitude of underreporting varies widely between studies and populations, and is dependant not only upon the population studied, but also the methods and administration of dietary assessment. Because of the expense involved, few studies utilize biomarkers of energy intake (i.e., doubly labeled

water) (15). An acceptable and more economical estimate of EI is the estimated basal metabolic rate (BMR_{est}) (16, 17). The purpose of the current study is to use the EI to BMR_{est} ratio to determine the extent of EI underreporting and associated factors in a Caribbean Latinos at high risk of developing type 2 diabetes.

SUBJECTS AND METHODS

Subjects

A total of 215 residents of Lawrence, Massachusetts, USA were enrolled in the Lawrence Latino Diabetes Prevention Project (LLDPP) from November 2004 to March 2007 (18). The goal of LLDPP was to implement and evaluate a diabetes prevention program for Caribbean Latinos at high risk of developing type 2 diabetes.

Subjects were eligible for the LLDPP if they: 1) had 30% chance of becoming diabetic within 7.5 years as predicted by the Stern formula (a model using age, sex, ethnicity, fasting glucose level, systolic blood pressure, HDL cholesterol level, waist, and immediate family history of diabetes) (19), 2) were 25 years of age and Latino, and 3) had a BMI 24 kg/m².

Baseline diet, physical activity, anthropometric, and demographic data from the LLDPP were used for this investigation. The institutional review boards of University of Massachusetts Medical School and the Greater Lawrence Family Health Center approved the study protocol.

Dietary assessment

Three unannounced 24HR were completed by telephone using the Nutritional Data System for Research (NDS-R versions 2005–2006, Minneapolis, MN) (20). The NDS-R utilizes the multiple-pass technique, allowing for several distinct opportunities to obtain information about the participant's food intake during the previous 24 hours. The NDS-R database includes culturally unique foods. All participants received a food portion visuals booklet prior to receiving the assessment calls to facilitate portion size estimation. All interviewers were bilingual (Spanish-English) registered dietitians, trained in the use of the software and dietary assessment methodology, and familiar with foods particular to this population. All calls were recorded; including time spent per call, and day of completion. Ten percent of calls were subject to more vigorous quality control measures, comparing data received to telephone recordings. All 215 subjects completed baseline 24HR, and all but two had 3 dietary recalls each (2 weekdays and 1 weekend call). Nutrient values were calculated from NDS-R, EI and percentage of calories from carbohydrate, protein, and fat were included in the analysis.

Basal metabolic rate estimation

The Mifflin St-Jeor Equation was chosen to estimate basal metabolic rate BMR_{est} because it provided the best estimation of age-specific energy intake of overweight and obese individuals (16, 17).

EI/BMR_{est} has been used extensively as a measure of the validity of energy intake in food intake studies (12, 21–25). Using data from whole-body calorimetry and doubly labeled water studies to determine energy expenditure, Goldberg and colleagues (26) suggested a cut-off limit of 1.55 for EI/BMR_{est} to evaluate energy intake data. EI/BMR_{est} ratio below this cut-off is incompatible with long-term survival (26). A lower ratio indicates underreporting and a higher ratio indicates overreporting of EI (27).

Assessment of physical activity, anthropometric, depression symptomatology, and demographic variables

Physical activity was assessed as part of the 24HR. This methodology has been used in several previous projects, and our group has validated it in a White population using both accelerometers and standard questionnaires (28). Data collected are summarized as metabolic equivalent task (MET) hours per day (MET-hr/day), based on the reported time spent at each activity and activity intensity level (29). MET is a physiological concept that expresses the energy cost (calories) of physical activities as multiples of resting metabolic rate. Body weight and height were measured using a scale calibrated every 6 months by the Division of Weights and Measures, City of Lawrence, Massachusetts, and a stadiometer using standard methodology (30). BMI was calculated as weight (kg)/height(m)².

Depressive symptomatology was assessed using the 20-item Center for Epidemiological Studies-Depression Scale (CES-D) (31). Patient demographic information was collected using a baseline questionnaire, and entered into Epi Info software program (version 6.04d January 2001), using double-entry to prevent entry error.

Statistical analyses

Subjects' characteristics were summarized using means (standard deviation) and frequencies (percent). To estimate underreporting, EI/BMR_{est} was computed. We examined the distribution of EI/BMR_{est} and found it was approximately normally distributed (see figure 1). To estimate expected caloric intake, we used BMR_{est} multiplied by a physical activity factor of 1.20, because our population was largely sedentary (32).

Linear regression analysis was used to evaluate factors associated with EI/BMR_{est}. The dependent variable was EI/BMR_{est}. Independent variables were evaluated separately and included demographics, BMI, physical activity, and depression score. The final, multivariable model was built in a forward stepwise manner, identifying the most strongly associated variable first (e.g., BMI). Variables were retained in the model based on the strength of support for the mechanism, in addition to statistical criteria such as percent change in coefficient and statistical significance levels.

RESULTS and DISCUSSION

Sample characteristics are reported in Table 1. The population was predominantly female, middle-aged, obese, poorly educated, unemployed, and 37% had siblings with diabetes. Reported total daily EI (1540 kcal/day) was barely higher than BMR_{est} (1496 kcal/day). Mean EI/BMR_{est} was 1.03 (SD=0.37), with a ratio of 1.55 expected for sedentary populations. When BMR_{est} was multiplied by an activity factor (1.20 for sedentariness),

expected caloric intake was 1794 kcal (SD=294), indicating underreporting by an average of 254 kcal/day.

An average total physical activity expenditure of 28.3 MET-hr/day; predominantly from household and occupational activity, is considered sedentary using our cutoff of <30 MET-hr/day, which is similar to other sedentary classifications (33). Half of subjects (52%) had a CES-D score 16, the conventional threshold for clinical depression.

Table 1 also presents bivariate results from linear regression analyses predicting EI/BMR_{est}. Higher BMI and lower percentages of calories from carbohydrate and protein were significantly associated with a lower EI/BMR_{est} ratio. In the final multivariate linear regression model (Table 2), EI/BMR_{est} was lower for Latinos with higher BMI ($b=-0.02$, $p<0.01$), having siblings with diabetes ($b=-0.09$, $p=0.07$), physical inactivity ($b=-0.04$, $p<0.05$), and being unemployed ($b=-0.12$, $p=0.04$).

Compared to other studies of dietary underreporting, EI/BMR_{est} was considerably lower in our population. A mean ratio of EI/BMR_{est} of 1.38 was reported from adults aged 18–64 years in Northern Ireland or the Republic of Ireland (34), and 1.44 in African-American women with type 2 diabetes (35). In the Third National Health and Nutrition Examination Survey, EI/BMR_{est} was 1.47 for men and 1.26 for non-pregnant women (7, 12). An EI/BMR_{est} population level of at least 1.55 is expected for a sedentary population (12), and the present sample satisfies the criteria of sedentary with less than 10% of energy expenditure at a moderate intensity of 4 METs or higher. This physical activity level is lower than the predominantly non-Latino Massachusetts healthy population of 30 met-hr/day (36).

Consistent with other studies, EI/BMR_{est} was lower for subjects with higher BMI. BMI tends to be highly correlated with adiposity (and lower energy expenditure) (37). The association of BMI with underreporting of energy intake using 24HR (or other dietary assessment tools) (2, 38, 39) has been ascribed to factors ranging from an inability to accurately perceive portion sizes (40) to social desirability bias (41).

In these data, unemployed participants underreported more than those working full time. Since the study population is fairly homogenous, we were unable to detect an association with education and income. In addition, Latinos having siblings with diabetes and those who were physically inactive were also more likely to underreport their EI, associations which have not been reported previously. Possible explanations include a social desirability bias (i.e., the defensive tendency to report behaviors more in keeping with the perception of social norms). This may be the result of an increased awareness of the connection between diet and diabetes or an awareness of diet in relation to body size. Unfortunately, we did not measure this trait.

Baseline measures were used in the analyses. For low-literacy participants, learning from written materials may be difficult, even when they are supplied with the appropriate visuals, and this can affect portion size estimation (42). This estimation requires an ability to remember portions of particular foods consumed and correlate this with two dimensional images of portion sizes, which is a trained ability. Recipe ingredients and portions are also difficult to report accurately, because many Latinos do not measure their foods, but

experientially replicate recipes learned from their older generations. In addition, meals are commonly prepared by other family members, further complicating the ability to describe ingredients. We found that reporting of fat, as a proportion of calories, is nearly 20% lower than expected (i.e., 26.5% vs. the US average of 32.8%) (43).

The Caribbean Latino community has distinct ideas of “good” foods, and “bad” foods, which do not necessarily coincide with ideas held by non-Latino populations (44). For example, instead of corn-based grains popular to Mexican Latinos, Caribbean Latinos favor rice as the staple grain, along with starchy vegetables such as yucca, green plantains, and cassava. The Spanish language also presents difficulty, as different vocabularies are used for the same food depending on the country of origin. However, our registered dietitian telephone callers were quite experienced in these diverse challenges, having worked with Caribbean Latinos for many years. Social trust is an important aspect of day-to-day interactions. Participant trust in the caller increased over time, with the callers reporting greater ease of assessment with subsequent calls. The first call took longer than subsequent calls because it included time spent with introductions, social conventions, and discussion of topics not directly related to dietary assessment.

To our knowledge, this is the first report of accuracy of dietary intake in Caribbean Latinos at elevated risk of type 2 diabetes, however, there are several limitations. First, this is a cross-sectional study; therefore, we can not establish a temporal relationship between underreporting and its associated factors. Second, we did not have a biomarker of EI; however, the validity of using ratio of EI/BMR_{est} to estimate underreporting has been demonstrated in previous studies. Finally, our results may not be generalized to all Latinos as participants in this study were predominantly females and Puerto Rican/Dominican.

CONCLUSIONS

Underreporting is found to be common in the Caribbean Latinos as indicated by a low EI/BMR_{est}, and accurate measurement of diet is influenced by factors such as BMI and lifestyle. Dietary assessment tools are needed for this unique population that encourages accurate reporting of foods, portion sizes, and ingredients. Dietary intake is a key component in diabetes prevention and outcome assessment, and further research into methodology aimed at correcting factors of underreporting for this population is warranted.

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Figure 1.
Distribution for ratio of energy intake to estimated basal metabolic rate Ratio of energy intake to estimated basal metabolic rate

Characteristics of study participants and bivariate results of simple linear regression models predicting ratio of energy intake to estimated basal metabolic rate (EI:BMR_{est}) (n=215), Lawrence Latino Diabetes Prevention Project (LLDPP)

Table 1

Demographic variable	Frequency	Mean	%/SD	Minimum	Maximum	b (SE) ^a	p value
Gender							
Male	50		23.3			-	
Female	165		76.7			0.02 (0.06)	0.74
Age (years)	51.5		11.11	26.6	79.1	-0.002 (0.002)	0.29
BMI (kg/m ²)	34.4		6.0	21.4	57.2	-0.02 (0.004)	<0.001
Height (cm)	159.8		8.8	141.0	193.0		
Weight (kg)	87.4		15.9	46.3	147.4		
BMI (kg/m ²)							
Thin to Normal (<25)	8		3.7			-	
Overweight (25–30)	40		18.6			-0.12 (0.14)	0.39
Obese (>30)	167		77.7			-0.23 (0.13)	0.08
Education							
Never attended school	5		2.4			-	
Some elementary school or high school	122		59.2			-0.18 (0.17)	0.30
High school or GED completed	46		22.3			-0.10 (0.17)	0.56
Vocational or tech school	10		4.9			0.13 (0.20)	0.53
University or College	23		11.2			-0.06 (0.18)	0.76
Smoking in the past 3 months (yes)	25		12.3			-0.04 (0.08)	0.60
Marital status							
Single	39		18.9			-0.11 (0.07)	0.13
Married or Living with Partner	107		51.9			-0.12 (0.08)	0.12
Separated, Divorced or Widowed	60		29.1				
Employment status							
Full-time	64		30.8			-	
Part-time	26		12.5			0.64 (10.69)	0.95
Unemployed	118		56.7			8.91 (7.20)	0.22

	Frequency/Mean	%/SD	Minimum	Maximum	b (SE) ^a	p value
Family history of diabetes or high blood sugar						
Father						
No	142	72.1			-	
Yes	37	18.8			2.43 (8.86)	0.78
Don't know / not sure	18	9.1			1.07 (11.75)	0.93
Mother						
No	133	67.5			-	
Yes	56	28.4			6.44 (7.48)	0.39
Don't know / not sure	8	4.1			-4.67 (17.07)	0.79
Sibling						
No	121	61.4			-	
Yes	72	36.6			-4.43 (7.05)	0.53
Don't know / not sure	4	2.0			-8.33 (23.84)	0.73
Dietary self-reported intake^b						
Energy intake (kcal/day)	1540.22	598.95	367.51	3657.58	0.001 (0.0005)	0.83
% calories from CHO	56.4	8.9	24.0	75.0	0.72 (0.35)	0.04
% calories from protein	17.7	5.44	8.48	60.24	1.59 (0.56)	0.005
% of calories from fat	26.5	6.28	11.76	47.1	-0.09 (0.50)	0.86
Estimated basal metabolic rate (kcal/day)	1495.74	245.08	983.86	2238.08		
Estimated BMR * 1.20 activity factor (Kcal/day)	1794.88	294.09	1180.64	1206.65		
Ratio of energy intake to estimated metabolic rate	1.03	0.37	0.27	2.03		
Physical activity (met^c-hours/day)						
Total	28.31	6.30	23.16	66.76	-0.10 (0.51)	0.84
Leisure time	0.91	1.36	0	10	-0.61 (2.29)	0.79
Household	4.37	2.93	0	17.58	-0.30 (1.10)	0.78
Occupational	4.23	8.93	0	55.33	-0.07 (0.38)	0.85
Psychosocial variable						
CES-D ^d Depression score	16.60	11.30	0	45	0.42 (0.28)	0.14
<10	65	30.23			-	
10-15	38	17.67			-2.46 (9.29)	0.79
>=16	112	52.09			6.73 (7.08)	0.34

	Frequency/Mean	%/SD	Minimum	Maximum	b (SE) ^a	p value
Stern index ^c	0.54	0.18	0.30	0.96	-3.87 (17.41)	0.82

^a b stands for regression coefficient (as an estimate of) and SE stands for its standard error.

^b dietary intake was from 24 hour recalls and represents 3 days.

^c met stands for metabolic equivalent task.

^d CES-D stands for Center for Epidemiologic Studies Depression Scale.

^e Stern index was calculated based on formula from the publication: Stern MP, Williams K, Haffner SM. Identification of persons at high risk for type 2 diabetes mellitus: do we need the oral glucose tolerance test? Ann Intern Med 2002; 136:575–581.

Table 2

Results of final linear regression models predicting ratio of energy intake to estimated basal metabolic rate (EI:BMRest), Lawrence Latino Diabetes Prevention Project (LLDPP)

Variable	b (SE) [†]	p value
BMI	−0.02 (0 .004)	<0.001
Siblings (Ref: no diabetes)	−0.09 (0.05)	0.07
Employment status (Ref: Full-time)		
Part-time	−0.21 (0.08)	0.01
Unemployed	−0.12 (0.06)	0.04
Leisure time	−0.04 (0.02)	0.05
physical activity		

[†] b stands for regression coefficient (as an estimate of β) and SE stands for its standard error.