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Permalink

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Journal

Journal of Immigrant and Minority Health, 13(1)

ISSN

1557-1912

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Publication Date

2011-02-01

DOI

10.1007/s10903-010-9332-x

Peer reviewed

Factors Associated with Overweight and Obesity among Children of Mexican Descent: Results of a Binational Study

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Published online: 9 March 2010

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Abstract The prevalence of childhood obesity is high among young children of Mexican origin in the United States, however, the determinants are poorly understood. We conducted a binational study with a sample from California (CA) and Mexico (MX), to identify and compare the most important factors associated with overweight and obesity among children of Mexican descent. Significantly more children were classified as overweight or obese in CA compared to MX (53.3 vs. 14.9%, $P < 0.01$). In CA and MX, having an obese mother was significantly associated with being overweight or obese. In MX, male gender, high socioeconomic status and very low food insecurity were associated with being overweight or obese. These data offer hypotheses for how migration may influence the high prevalence of overweight among the Mexican children in California.

Keywords Children · Obesity · Mexican immigrants · Transnational

Introduction

The prevalence of childhood obesity has increased dramatically in the United States (US) over the past 30 years [1–4], especially among young children of Mexican origin [5]. Approximately 33% of young Mexican-American children in the US are considered overweight or obese, which is higher than both non-Hispanic white (25%) and black (24%) children [6]. Overweight children are more likely to become overweight adults [7–9] and adults of Mexican origin are at increased risk for morbidities associated with obesity, such as diabetes, cardiovascular disease and uncontrolled hypertension compared to other racial and ethnic groups [10–14]. Yet the determinants of childhood obesity in this population are not well understood.

Acculturation is a frequently studied determinant of obesity among children of Mexican descent [15–27]. However, while the literature has supported an increased risk of obesity with increasing acculturation among Mexican-American adults [28–33], the association in children remains unclear [34]. A more complete understanding of the obesity epidemic among children of Mexican descent may come from transnational research (US-Mexico) given the close proximity of the two countries as well as the strong ties between immigrants and their communities of origin. The determinants of childhood obesity among children of Mexican descent are likely to be different depending on whether they reside in Mexico or the US [35]. Programs and policies aimed at preventing and reducing obesity among children of Mexican descent in the

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US will benefit from a better understanding of the factors that contribute to obesity on both sides of the border. Such a binational strategy was recommended by the Institute of Medicine in a recent report on preventing overweight in Latino children [36].

Mexico is currently undergoing a transition, where problems of nutritional deficit (stunting, micronutrient deficiencies) and infectious disease now coexist with an industrialized country profile of obesity and chronic disease [35, 37, 38]. As part of this transition, the prevalence of childhood overweight has been increasing [39] and studies in Northern Mexico and Mexico City have shown prevalence estimates similar to the US [40–42].

Using a transnational study design, the aim of this study was to identify and compare the most important factors associated with overweight and obesity among Mexico-born and California-born children of Mexican descent.

Methods

Study Design and Participants

We conducted a binational study using two cross-sectional samples of 5-year-old children and their mothers in California and Mexico. The mothers and children from California were participants of the Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS) study, a longitudinal birth cohort in the agricultural Salinas Valley. Pregnant women were recruited from 1999 to 2000 in prenatal clinics serving a predominantly low-income, Spanish-speaking population. Detailed methods for this longitudinal study have been published previously [43, 44]. Of 601 women initially enrolled, 526 were followed through delivery of a live singleton birth that survived the neonatal period, and 350 follow-up interviews were completed when the children were 5-years-old. Mothers born in the US ($n = 45$) and children with incomplete anthropometric information ($n = 18$) were excluded for a final sample size of 287 mother-child pairs of whom all children were born in the US and all mothers born in Mexico. Children with missing anthropometric information were more likely to have obese mothers and mothers who were recent immigrants to the US than children without missing data ($P < 0.05$).

Mexican 5-year-old children were participants in the Proyecto Mariposa study. Proyecto Mariposa was designed to capture a sample in Mexico that closely resembled the California sample but had not migrated. In the California cohort, Mexican-born women were most commonly from the states of Guanajuato (20%), Jalisco (12%) and Michoacán (24%) with other states of origin each representing less than 5% of the study population. Thus, Proyecto

Mariposa included women, who had never migrated themselves, and their 5-year-old children from high-migration municipalities in these states defined as having at least 10% of the male population residing in the US in the majority of towns and districts within the municipality as of the most recent Mexican census in 2005 [45]. We recruited women and their 5-year-old children who were beneficiaries of the social welfare program, *Oportunidades*, to obtain a population similar to the California sample that was also receiving government benefits (Special Supplemental Nutrition Program for Women, Infants and Children) and accessing health care. Of 317 mother-child pairs in the Proyecto Mariposa sample, 316 children had complete anthropometric information and were included in this analysis.

Institutional Review Boards at UC Berkeley and the National Public Health Institute in Mexico approved this study.

Measures

Face-to-face interviews were conducted and identical anthropometric protocols were followed in California and Mexico. Mothers provided informed consent for themselves and their children.

Outcome definition: Children were weighed and measured using calibrated electronic scales (Tanita Mother-Baby Scale Model 1582, Tanita Corp.) and stadiometers. Each child was measured in triplicate and the average of the measurements was used. Standardization procedures were conducted in each site. In MX, interviewers participated in a standardization procedure before the study began at a local school where interviewers each measured the same child until agreement was reached. In CA, where interviewers had considerable experience conducting anthropometric assessments as a result of previous study visits at 6 months, 1, 2 and 3.5 years, we conducted pilot testing where the two different interviewers took measurements until agreement was reached. We calculated body mass index (BMI) as mass in kilograms divided by height in meters squared and for both samples, compared to sex-specific BMI-for-age percentile data issued by the Centers for Disease Control and Prevention (CDC) in 2000 [46]. We classified children who were at or above the 85th percentile but less than the 95th percentile as overweight and those at or above the 95th percentile as obese [46].

Independent variables: We calculated median daily hours playing outside and watching television based on mother's report of average time spent in these activities on a typical weekend and weekday. The questions regarding television viewing were part of the Home Observation for the Measurement of the Environment Short Form (HOME-SF), a previously validated and widely used questionnaire.

Frequency of intake of foods shown to be associated with child weight in the literature [47] including sodas, other sweetened beverages, fast food, sweets and snacks, fruits and vegetables were assessed through maternal report using a quantitative food frequency questionnaire (FFQ). For food groups such as sweets and snacks as well as fruits and vegetables, the FFQ included the most commonly consumed items in the respective country.

Mother's height and weight were measured using an electronic Tanita scale (Tanita Mother-Baby Scale Model 1582, Tanita Corp.) and stadiometer. Mother's weight status was defined as overweight if her BMI was greater than or equal to 25 and less than 30 and obese if her BMI was 30 or greater [48]. Total time spent in the US was used as a proxy for acculturation in the California sample given that all women were foreign-born and the majority was monolingual Spanish-speaking [49]. In Mexico, women were asked if the child's father or the current head of household or any other close family member, including her grandparents, parents, siblings or other children had migrated to the US for work and if any of them were currently residing in the US.

Household food insecurity during the past 12 months was measured using the US Household Food Security Instrument, Spanish Version (Short Form) in both locations [50, 51]. Households were classified as: food secure, low food secure, and very low food secure according to US Department of Agriculture guidelines [50]. A different measure of socioeconomic status (SES) was used in each country that differentiated between low, medium and high SES levels within each sample, without reference to the larger community. Among the California mothers, 97% were receiving WIC and the Mexico mothers were recruited from Oportunidades, which targets the lowest 20th percentile of economic well-being in the country. In the California study, SES was measured using a continuous measure of per capita household income divided into tertiles. In Mexico, a developing country where income measures do not accurately characterize SES [52], we used a principal component analysis to summarize housing characteristics and assets and the first principal component weightings were retained [53]; a weighted score was calculated for each woman, and the weighted scores were divided into tertiles. Housing characteristics and assets included type of house (owned, rented, borrowed, shared, mortgaged, given as benefit of employment), floor (dirt, cement, wood/tile/other finish), sanitary service (none, latrine, toilet with no plumbing, toilet with plumbing), and kitchen (no separate room, a separate room where people also sleep, a separate room where no one sleeps), as well as televisions (none, black and white, color, more than one color), cars (none, one old, one new, more than one), number of household appliances (VCR, DVD player, CD

player, tape player, microwave, washer, computer, printer, air conditioner and home phone) and number of light bulbs.

Statistical Analysis

Statistical analyses were conducted using STATA 10.0 for Windows [54].

We used chi-square tests and Fisher's exact tests in the case of small cell sizes to compare the California and Mexico samples according to several demographic and health behavior characteristics. Within the California sample, we also compared children according to mother's length of residence in the US.

We used logistic regression to determine and compare the most important determinants for being classified as overweight or obese (≥ 85 th percentile) in California and Mexico. For the crude analysis, we chose demographic and behavioral variables that have been shown in the literature to be associated with children's weight status [47] or that we hypothesized a priori to be associated with children's weight status in this population. For the California sample, we repeated the crude analysis using the 95th percentile cutoff for obesity because of the high number of children in this category. For the multivariate logistic regression analysis, we considered variables for inclusion if they were related to the outcome ($P < 0.1$) in the crude analysis for either sample or if they were of interest a priori. For each sample, we used a manual backwards stepwise elimination procedure removing the variables from the model one at a time using the likelihood ratio test to determine if the model's fit improved using a cutoff of $P < 0.05$. For the California sample, we reran the final model using the 95th percentile cutoff.

Results

Compared to California-born children, Mexico-born children were more likely to have been breastfed exclusively for 6 months, to have a mother with fewer years of education and not actively engaged in the workforce, and to live in a household that experienced more food insecurity (Table 1). Compared to the Mexico-born children, children in California watched more television, ate fast food more frequently, and consumed more fruit, as reported by the mothers. Mothers in Mexico reported that their children consumed more soda and spent more time playing outside than mothers in California. Intake of sweets, snacks and vegetables did not differ between groups.

The prevalence of overweight and obesity in mothers was high in both samples, with obesity significantly higher in California (49%) compared to Mexico (33%) ($P < 0.01$). More than 40% of mothers in Mexico reported

Table 1 Selected socio-demographic characteristics and health behaviors of participants, California (Salinas, CA) and Mexico (Guanajuato, Jalisco, and Michoacán, Mexico) 2006

Characteristic/behavior	Mexico		California		P-value	California: mother's years in the US						P-value
	n = 316		n = 287			5–10 years n = 160		11–15 years n = 92		16 years or more n = 53		
	n	(%)	n	(%)		n	(%)	n	(%)	n	(%)	
Child sex					0.98							0.80
Male	149	(47.2)	135	(47.0)		71	(49.0)	40	(44.9)	24	(45.3)	
Female	167	(52.9)	152	(53.0)		74	(51.0)	49	(55.1)	29	(54.7)	
Exclusively breastfed ≥ 6 months					<0.01							0.47
No	216	(68.4)	250	(87.7)		128	(88.9)	75	(84.3)	47	(90.4)	
Yes	100	(31.7)	35	(12.3)		16	(11.1)	14	(15.7)	5	(9.6)	
Mother's weight status					<0.01							0.10 ^b
Normal	78	(24.7)	37	(12.9)		24	(16.6)	9	(10.1)	4	(7.6)	
Overweight	132	(41.8)	110	(38.3)		61	(42.1)	32	(36.0)	17	(32.1)	
Obese	106	(33.5)	140	(48.8)		60	(41.4)	48	(53.9)	32	(60.4)	
Mother's education					<0.01							0.30
Elementary or less	217	(68.7)	142	(49.5)		66	(45.5)	51	(57.3)	25	(47.2)	
Middle or high school	93	(29.4)	101	(35.2)		52	(35.9)	27	(30.3)	22	(41.5)	
High school graduate or more	6	(1.9)	44	(15.3)		27	(18.6)	11	(12.4)	6	(11.3)	
Married or living as married					0.05							0.66
No	21	(6.7)	32	(11.2)		14	(9.7)	12	(13.5)	6	(11.3)	
Yes	295	(93.4)	255	(88.9)		131	(90.3)	77	(86.5)	47	(88.7)	
Mother's work status					<0.01							0.27 ^b
Not working	203	(64.0)	86	(28.2)		48	(30.0)	27	(29.4)	11	(20.8)	
Work less than 20 h/week	54	(17.0)	15	(4.9)		6	(3.8)	4	(4.4)	5	(9.4)	
Work 20–40 h/week	22	(6.9)	68	(22.3)		31	(19.4)	20	(21.7)	17	(32.1)	
Work more than 40 h/week	38	(12.0)	136	(44.6)		75	(46.9)	41	(44.6)	20	(37.7)	
Household food insecurity					<0.01							0.50 ^b
Secure	78	(24.7)	172	(59.9)		93	(64.1)	50	(56.2)	29	(54.7)	
Low food security	149	(47.2)	87	(30.3)		39	(26.9)	28	(31.5)	20	(37.7)	
Very low food security	89	(28.2)	28	(9.8)		13	(9.0)	11	(12.4)	4	(7.6)	
Family member currently in US ^a												
No	176	(55.7)										
Yes	140	(44.3)										
Daily TV time					<0.01							0.36
1 h or less	138	(43.7)	85	(29.6)		49	(33.8)	26	(29.2)	10	(18.9)	
1–2 h	85	(26.9)	101	(35.2)		47	(32.4)	33	(37.1)	21	(39.6)	
Greater than 2 h	93	(29.4)	101	(35.2)		49	(33.8)	30	(33.7)	22	(41.5)	
Time spent playing outside					<0.01							0.78
1 h or less	41	(13.0)	113	(39.4)		57	(39.3)	34	(38.2)	22	(41.5)	
2–3 h	141	(44.6)	124	(43.2)		59	(40.7)	41	(46.1)	24	(45.3)	
4 h or more	134	(42.4)	50	(17.4)		29	(20.0)	14	(15.7)	7	(13.2)	
Soda consumption ^c					<0.01							0.20 ^b
Less than 1 per week	73	(23.1)	110	(38.3)		59	(40.7)	27	(30.3)	24	(45.3)	
1–6 per week	189	(59.8)	153	(53.3)		77	(53.1)	53	(59.6)	23	(43.4)	
1 a day or more	54	(17.1)	24	(8.4)		9	(6.2)	9	(10.1)	6	(11.3)	
Other sweetened beverage consumption ^c					<0.01							0.37
Less than 1 per day	196	(62.0)	112	(39.0)		64	(44.1)	29	(32.6)	19	(35.9)	
1 to less than 2 per day	71	(22.5)	54	(18.8)		26	(17.9)	16	(18.0)	12	(22.6)	
2 or more per day	49	(15.5)	121	(42.2)		55	(37.9)	44	(49.4)	22	(41.5)	

Table 1 continued

Characteristic/behavior	Mexico		California		P-value	California: mother's years in the US						P-value				
	<i>n</i> = 316		<i>n</i> = 287			5–10 years <i>n</i> = 160		11–15 years <i>n</i> = 92		16 years or more <i>n</i> = 53						
	<i>n</i>	(%)	<i>n</i>	(%)		<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)					
Fast food consumption												<0.01	0.07			
Less than once per week	271	(86.0)	104	(36.5)							60	(42.0)	31	(34.8)	13	(24.5)
Once a week or more	44	(14.0)	181	(63.5)							83	(58.0)	58	(65.2)	40	(75.5)
Sweets and fried snacks consumption ^c												0.31	0.08			
Less than 1 per day	58	(18.4)	41	(14.3)							16	(11.0)	16	(18.0)	9	(17.0)
1 to less than 2 per day	93	(29.4)	81	(28.2)							50	(34.5)	16	(18.0)	15	(28.3)
2 or more per day	165	(52.2)	165	(57.5)							79	(54.5)	57	(64.0)	29	(54.7)
Fruit consumption ^c												<0.01	0.39 ^b			
Less than 1 per day	113	(35.8)	16	(5.6)							5	(3.5)	7	(7.9)	4	(7.6)
1–2 per day	115	(36.4)	43	(15.0)							24	(16.6)	10	(11.2)	9	(17.0)
2 per day or more	88	(27.9)	228	(79.4)							116	(80.0)	72	(80.9)	40	(75.5)
Vegetable consumption ^c												0.25	0.47			
Less than 1 per day	25	(7.9)	34	(11.9)							13	(9.0)	15	(16.9)	6	(11.3)
1–2 per day	82	(26.0)	68	(23.7)							35	(24.1)	19	(21.4)	14	(26.4)
2 per day or more	209	(66.1)	185	(64.5)							97	(66.9)	55	(61.8)	33	(62.3)

^a Family member includes child's father or the current head of household and the mother's grandparents, parents, siblings, or other children
^b Fisher's exact test used due to small cell sizes
^c Mother's report of how many times the child consumed the item, serving sizes were not specified

that their partner or other close family member was currently living in the US with California as the most common destination state reported (data not shown). The length of time mothers in California had lived in the US at the time of the interview was not significantly associated with any of the demographic characteristics, physical activity indicators, or dietary intake levels.

Significantly more children were classified above the 85th percentile in California compared to Mexico (53.3 vs. 14.9%, $P < 0.01$) (Fig. 1). No significant differences in weight status were detected in the California sample by mother's years in the US.

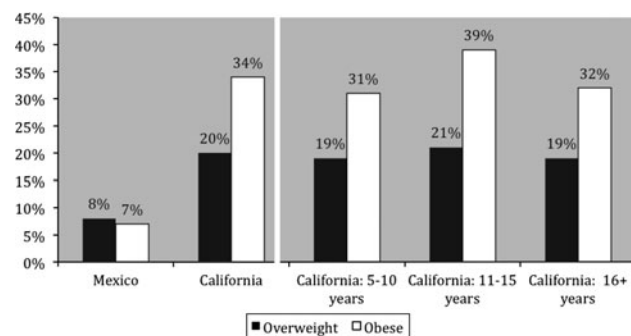


Fig. 1 Children's weight status in Mexico, California, and California by mother's years in US

As shown in Tables 2 and 3, in the California sample, having an obese mother was significantly associated with being overweight or obese (>85th percentile of BMI) in both the crude (OR 2.5 95% CI 1.2, 5.2) and adjusted analysis (OR 2.4 95% CI 1.1, 5.3). Although there was a non-significant trend ($P = 0.1$) towards higher prevalence of overweight among children of mothers who had been in the US longer (11–15 years vs. 5–10 years), this association disappeared in the multivariate model. When we reran the California model separately using the 95th percentile cutoff instead of the 85th percentile (data not shown), our findings for the crude and adjusted analysis did not change significantly.

Among the Mexico-born children, having an obese mother also significantly increased the odds of the child being overweight or obese in both the crude (OR 5.4 95% CI: 1.8, 16.3) and adjusted models (OR 5.5 95% CI: 1.8, 17.1). Very few children, however, who were classified above the 85th percentile had mothers in the normal weight category ($n = 4$) so these analyses should be interpreted with caution. In both the crude and adjusted analyses for the Mexico sample, we found that children's weight status was significantly associated with sex, socioeconomic status, and household food insecurity. In the multivariate model, girls had half the odds of being classified above the 85th percentile compared to boys (OR 0.5 95% CI: 0.2, 0.9); children in the highest SES tertile had three times the

Table 2 Selected characteristics and behaviors and crude odds ratios with 95% confidence intervals for weight status, California (Salinas, CA) and Mexico (Guanajuato, Jalisco, and Michoacán, Mexico) 2006

Characteristic/behavior	Mexico				Crude OR	95% confidence interval	California			
	<i>n</i> = 316						<i>n</i> = 287			
	<85th%		≥85th%				<85th%		≥85th%	
	<i>n</i>	(%)	<i>n</i>	(%)			<i>n</i>	(%)	<i>n</i>	(%)
Total ^a	269	(85.1)	47	(14.9)			134	(46.7)	153	(53.3)
Sex										
Male	121	(81.2)	28	(18.8)	1.0		65	(48.2)	70	(51.9)
Female	148	(88.6)	19	(11.4)	0.6	(0.3,1.0) [‡]	69	(45.4)	83	(54.6)
Mother's weight status										
Normal	74	(94.9)	4	(5.1)	1.0		22	(59.5)	15	(40.5)
Overweight	113	(85.6)	19	(14.4)	3.1	(1.0,9.5) [†]	60	(54.6)	50	(45.5)
Obese	82	(77.4)	24	(22.6)	5.4	(1.8,16.3) [†]	52	(37.1)	88	(62.9)
Exclusively breastfed ≥6 months										
No	83	(83.0)	17	(17.0)	1.3	(0.7,2.4)	17	(48.6)	18	(51.4)
Yes	186	(86.1)	30	(13.9)	1.0		116	(46.4)	134	(53.6)
Socioeconomic Status ^b										
Tertile 1	95	(90.5)	10	(9.5)	1.0		62	(47.0)	70	(53.0)
Tertile 2	87	(83.7)	17	(16.4)	1.9	(0.8,4.3)	27	(45.0)	33	(55.0)
Tertile 3	85	(81.0)	20	(19.1)	2.2	(1.0,5.0) [†]	44	(46.8)	50	(53.2)
Mother's education										
Elementary or less	187	(86.2)	30	(13.8)	1.0		61	(43.0)	81	(57.0)
Middle or high school	76	(81.7)	17	(18.3)	1.4	(0.7,2.7)	53	(52.5)	48	(47.5)
High school graduate or more	6	(100.0)	0	(0.0)			20	(45.5)	24	(54.6)
Married or living as married										
No	20	(95.2)	1	(4.8)	0.3	(0.0,2.1)	18	(56.3)	14	(43.8)
Yes	249	(84.4)	46	(15.6)	1.0		116	(45.5)	139	(54.5)
Mother's work status										
Not working	175	(86.6)	27	(13.4)	1.0		39	(46.4)	45	(53.6)
Work less than 20 h/week	42	(77.8)	12	(22.2)	1.9	(0.9,4.0)	10	(66.7)	5	(33.3)
Work 20–40 h/week	20	(90.9)	2	(9.1)	0.6	(0.1,2.9)	30	(44.8)	37	(55.2)
Work more than 40 h/week	32	(84.2)	6	(15.8)	1.2	(0.5,3.2)	55	(45.5)	66	(54.6)
Household food insecurity										
Secure	71	(91.0)	7	(9.0)	1.0		81	(47.1)	91	(52.9)
Low food security	127	(85.2)	22	(14.8)	1.8	(0.7,4.3)	42	(48.3)	45	(51.7)
Very low food security	71	(79.8)	18	(20.2)	2.6	(1.0,6.5) [†]	11	(39.3)	17	(60.7)
Daily TV time										
1 h or less	120	(87.0)	18	(13.0)	1.0		27	(45.9)	36	(54.1)
1–2 h	68	(80.0)	17	(20.0)	1.7	(0.8,3.4)	42	(49.5)	45	(50.5)
Greater than 2 h	81	(87.1)	12	(12.9)	1.0	(0.5,2.2)	65	(44.6)	72	(55.5)
Time spent playing outside										
1 h or less	31	(75.6)	10	(24.4)	1.0		50	(44.3)	63	(55.8)
2–3 h	124	(87.9)	17	(12.1)	0.4	(0.2,1.0)	63	(50.8)	61	(49.2)
4 h or more	114	(85.1)	20	(14.9)	0.5	(0.2,1.3)	21	(42.0)	29	(58.0)
Soda consumption ^c										
Less than 1 per week	68	(93.2)	5	(6.9)	1.0		55	(50.0)	55	(50.0)
1–6 per week	153	(81.0)	36	(19.1)	3.2	(1.2,8.5) [†]	70	(45.8)	83	(54.3)
1 a day or more	48	(88.9)	6	(11.1)	1.7	(0.5,5.9)	9	(37.5)	15	(62.5)

Table 2 continued

Characteristic/behavior	Mexico				Crude OR	95% confidence interval	California					
	<i>n</i> = 316						<i>n</i> = 287					
	<85th%		≥85th%				<85th%		≥85th%			
	<i>n</i>	(%)	<i>n</i>	(%)			<i>n</i>	(%)	<i>n</i>	(%)		
Other sweetened beverage consumption^c												
Less than 1 per day	166	(84.7)	30	(15.3)	1.0		50	(44.6)	62	(55.4)	1.0	
1 to less than 2 per day	61	(85.9)	10	(14.1)	0.9	(0.4,2.0)	23	(42.6)	31	(57.4)	1.1	(0.6,2.1)
2 or more per day	42	(85.7)	7	(14.3)	0.9	(0.4,2.2)	61	(50.4)	60	(49.6)	0.8	(0.5,1.3)
Fast food consumption												
Less than once per week	260	(86.4)	46	(13.7)	1.0		47	(45.2)	57	(54.8)	1.0	
Once a week or more	8	(77.3)	1	(22.7)	1.9	(0.8,4.1)	86	(47.5)	95	(52.5)	0.9	(0.6,1.5)
Sweets and snacks consumption^c												
Less than 1 per day	47	(81.0)	11	(19.0)	1.0		18	(43.9)	23	(56.1)	1.0	
1 to less than 2 per day	83	(89.3)	10	(10.8)	0.5	(0.2,1.3)	36	(44.4)	45	(55.6)	1.0	(0.5,1.2)
2 or more per day	139	(84.2)	26	(15.8)	0.8	(0.4,1.7)	80	(48.5)	85	(51.5)	0.8	(0.4,1.7)
Fruit consumption^c												
Less than 1 per day	96	(85.0)	17	(15.0)	1.0		9	(56.3)	7	(43.8)	1.0	
1–2 per day	96	(86.5)	19	(16.5)	1.1	(0.5,2.3)	21	(48.8)	22	(51.2)	1.3	(0.4,4.3)
2 per day or more	77	(87.5)	11	(12.5)	0.8	(0.4,1.8)	104	(45.6)	124	(54.4)	1.5	(0.6,4.3)
Vegetable consumption^c												
Less than 1 per day	21	(84.0)	4	(16.0)	1.0		18	(52.9)	16	(47.1)	1.0	
1–2 per day	68	(82.9)	14	(17.1)	1.1	(0.3,3.6)	27	(39.7)	41	(60.3)	1.7	(0.7,3.9)
2 per day or more	180	(86.1)	29	(13.9)	0.8	(0.3,2.6)	89	(48.1)	96	(51.9)	1.2	(0.6,2.5)
Mother's years in the US												
5–10 years							73	(50.3)	72	(49.7)	1.0	
11–15 years							35	(39.3)	54	(60.7)	1.6	(0.9,2.7) [‡]
16+ years							26	(49.1)	27	(50.9)	1.1	(0.6,2.0)
Family member currently in US^d												
No	116	(82.9)	24	(17.1)	1.0							
Yes	153	(86.9)	23	(13.1)	0.7	(0.4,1.4)						

^a Row percentages

^b Socioeconomic status was determined by a principal component analysis of housing characteristics and assets in Proyecto Mariposa

^c Mother's report of how many times the child consumed the item, serving sizes were not specified

^d Family member includes child's father or the current head of household and the mother's grandparents, parents, siblings, or other children

[†] $P < 0.05$; [‡] $P < 0.10$

odds of being overweight or obese compared to children in the lowest SES tertile (95% CI: 1.3, 7.5); and children experiencing very low food security had almost four times the odds compared to children from food secure households (OR 3.8 95% CI: 1.4, 10.6).

Discussion

The main findings of this binational study were: (1) the prevalence of childhood obesity was much higher among children of Mexican descent in the US than in Mexico; (2)

maternal obesity was a determinant of childhood obesity in both settings and (3) in Mexico, male gender, high SES and low food security were determinants of childhood obesity.

The difference in prevalence of overweight and obesity was much greater than expected based on previous research. One-third of Mexican-American children ages two to five were above the 85th percentile in NHANES (2003–2004) [6] compared to 53% of 5-year-olds in California. Also, the 2003 Mexican National Social Welfare Survey, which surveys *Oportunidades* participants, found that 24% of non-indigenous children 49–60 months old were classified as overweight or obese, using International

Table 3 Multivariate model of predictors of overweight and obesity (\geq 85th percentile), California (Salinas, CA) and Mexico (Guanajuato, Jalisco, and Michoacán, Mexico) 2006

	Mexico		California	
	Adjusted odds ratio ^a	(95% CI)	Adjusted odds ratio ^a	(95% CI)
Mother's weight status				
Normal	ref		ref	
Overweight	3.1	(1.0,9.6)	1.2	(0.6,2.6)
Obese	5.5	(1.8,17.1) [‡]	2.4	(1.1,5.3) [†]
Sex				
Male	ref		ref	
Female	0.5	(0.2,0.9) [†]	1.1	(0.7,1.8)
Socioeconomic status				
Tertile 1	ref		ref	
Tertile 2	2.0	(0.8,4.9)	1.1	(0.6,2.1)
Tertile 3	3.1	(1.3,7.5) [‡]	1.0	(0.5,1.7)
Household food insecurity				
Secure	ref		ref	
Low food security	2.1	(0.8,5.2)	0.8	(0.5,1.4)
Very low food security	3.8	(1.4,10.6) [‡]	1.3	(0.5,3.0)

^a Adjusted for all other variables listed

^b Socioeconomic status was determined by a principal component analysis of housing characteristics and assets in Proyecto Mariposa

[†] $P \leq 0.05$; [‡] $P \leq 0.01$

Obesity Task Force (IOTF) criteria [55], which is higher than the 15% we observed. A prevalence of 15% is what is normally expected to be at or above the 85th percentile. Thus, this population may not be representative of other non-indigenous areas where the prevalence is higher. Similarly, 5% of non-indigenous children 49–60 months old were concurrently obese and stunted in this national survey, which occurred in less than 1% of the children in our Mexican sample (data not shown).

In Mexico, male children were more likely to be overweight compared to female children. Nationally representative surveys in Mexico as well as Mexican-Americans in the US have also documented this gender difference in childhood obesity. The 2003 Mexican National Social Welfare Survey showed that males were more likely to be obese than females [55]. Similarly, among Mexican-American children ages two to five surveyed in NHANES (2003–2004), 38% of males were overweight or obese compared to 27% of females [6]. However, we did not document a sex difference among children in the California sample. It is possible that in the face of limited food resources in Mexico, resources are more likely to be devoted to boys than girls but this may not be the case in California.

Higher SES was associated with increased odds of childhood obesity in the Mexican sample. Two other studies of *Oportunidades* participants have also found that

SES was positively associated with child obesity [55, 56]. Families with relatively higher SES levels may have increased resources to procure foods that may lead to obesity. In fact, further analyses of these data showed that children in the highest SES tertile in Mexico consumed sweets and fried snacks significantly more often than children in the lower SES tertiles ($P = 0.03$). There was no difference in the odds of overweight or obesity according to SES among children in the California sample. Although lower SES has been associated with an increased risk of childhood obesity in the US [57], it may not apply within a predominantly poor sample, such as this one, in contrast to Mexico.

Additionally, in Mexico, where approximately three-quarters of the households experienced some degree of food insecurity in the last 12 months, we found that food insecurity was associated with child obesity. Food insecurity could lead to childhood obesity through mechanisms that have been proposed in the literature, such as over reliance on inexpensive, energy-dense foods [58], overeating when food is available [58] and changes in metabolism that favor more efficient use of energy [59]. A previous analysis using these data revealed that children experiencing low or very low food security consumed less of the majority of food categories except for beans compared to children from food secure households [60]. Thus, explanations for the food insecurity-obesity connection

appear to be explained by hypotheses involving cyclical eating patterns or metabolic changes, which would not be captured by a food frequency questionnaire.

Only one study has been conducted on household food insecurity and weight status among children in Mexico. This study found that household food insecurity was associated with being overweight among children aged 9–15 in a low-income area of Mexico City [61]. However, research on food insecurity and child weight status in the US and other countries has been equivocal, with some studies showing that food insecurity is associated with obesity or a higher BMI [59, 62–66], other studies showing an association between food insecurity and lower BMI [67, 68], and others showing no association [69–72]. Different findings may be related to differences in study populations; the participants in our study were all participants in the *Oportunidades* program and from the lowest 20th percentile of income in Mexico. Household food insecurity was not associated with child weight status in the California sample, although further analyses showed that it was associated with maternal obesity (data not shown). It could be that food insecurity was not as severe in the California sample and thus children were spared the effects. Longitudinal and in-depth qualitative research is needed to better understand the association between food security and child weight status.

We found that *high* SES and household food insecurity were both independently associated with childhood obesity in Mexico. This may be a result of the characteristics of the Mexican sample. All families in the Mexico sample were poor as they were drawn from the lowest 20th percentile of income in Mexico and a high percentage of mothers in each SES tertile reported food insecurity (83–64%). Although our numbers were small, it appeared that the prevalence of overweight and obesity for those in food insecure households was similar among all levels of SES (19–22%) i.e. there was no evidence of interaction between food insecurity and SES. Alternatively, this may be explained by the measure of food insecurity. Because food insecurity measures mothers' *perception* of having enough food for the family, it is possible that mothers in the highest SES group still worry about not having enough food. Additionally, it could be that previously mentioned mechanisms, such as cyclical eating and metabolic changes, operate at all levels of SES. Additional research exploring the economic factors explaining the associations of SES and food insecurity with obesity are needed.

Maternal weight status was a strong correlate of child weight status in both the Mexican-American and Mexican children sampled, which has also been shown in other studies [73, 74]. Although this may suggest a genetic component to weight status, mother's weight status may also reflect characteristics of the environment shared with

the child, which may be more important [75]. In addition, maternal weight status may also influence child weight status during the prenatal period [76]. Research has shown that overweight and obese mothers are more likely to gain excessive weight during pregnancy and excessive weight gain during pregnancy has been shown to be associated with subsequent childhood overweight [76]. Research is needed to examine the effect of gestational weight gain in Mexican mothers.

We did not find evidence to support the acculturation hypothesis in this study using maternal length of residence in the US as a proxy. Other research in younger children has also failed to document an association [20, 21, 23, 26]. It is possible that we did not observe an association between acculturation and children's weight status because the California sample was recruited from a relatively homogenous population of low-income Mexican immigrant farmworkers. Alternatively, time in the US may have been an insufficient indicator for measuring the domain(s) of acculturation important for childhood obesity [77].

This study had several limitations. First, although we made every attempt to recruit comparable samples and collect equivalent data in each site, our samples may have been too different and data collection instruments incapable of collecting the same information in both sites. Thus, making comparisons may be difficult. Second, we relied on maternal report of diet and physical activity. Mothers may not have been able to accurately report their child's regular dietary intake or physical activity levels especially if she worked outside the home, as was the case for 58% of the mothers in California and 34% of the mothers in Mexico. Furthermore, although diet was measured using previously validated instruments, the physical activity variable was not. Third, we used the short form to measure household food insecurity, which may not have provided as complete a picture of food insecurity compared to the long form. Finally, this was a cross-sectional study, which does not permit us to infer any causality.

Our binational study findings clearly show that children of Mexican descent living in California are at increased risk for being overweight compared to children that remain in sending communities in Mexico. Our results suggest that successful programs and policies addressing childhood obesity in both countries should include mothers or perhaps the entire family. Additionally, interventions on both sides of the border should take into consideration the effects of gender, SES and food security on obesity among children in Mexico. For example, in the US, interventions should acknowledge that, obesity, although undesirable from a health perspective, may be a sign of desirable increases in SES in immigrants' communities of origin.

Acknowledgments This research was made possible by funding provided by National Institute of Environmental Health Sciences (PO1 ES009605), the Environmental Protection Agency (RD 83171001), UC-Mexus, University of California Berkeley Health Initiative of the Americas, University of California Berkeley Center for Latino Policy Studies, University of California Institute for the Study of Social Change, and the W.K. Kellogg Foundation Postdoctoral Fellowship.

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