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Original Research

Es Niño o Niña?: Gender Differences in Feeding Practices and Obesity Risk among Latino Infants

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A B S T R A C T

Background: Obesity prevalence is significantly higher among Latino boys than girls. Weight status at 12 mo, a significant predictor of childhood obesity, is associated with feeding practices during infancy.
Objectives: The objectives were to examine breastfeeding and formula-feeding practices overall and by infant gender and to examine relations among infant gender, milk-feeding practices, and obesity risk among Latino infants over the first year of life.
Methods: Latino mother–infant dyads ($n = 90$) were recruited from a pediatric clinic. Mothers were interviewed at regular intervals (infants aged 2, 4, 6, and 9 mo), and 24-h feeding recalls were conducted when infants were aged 6 and 9 mo. Infants' lengths and weights were retrieved from clinic records to calculate weight-for-length percentiles. A bivariate analysis was conducted to compare feeding practices by gender and mediation analysis to test whether feeding practices mediated the relation between gender and obesity risk.
Results: The majority (80%) of mothers were born outside the United States. In early infancy, mixed feeding of formula and breastfeeding was common. At 6 and 9 mo of age, milk-feeding practices differed, with formula feeding more common for boys than girls. At 12 mo, 38% of infants experienced obesity risk (≥85th weight-for-length percentile). Infants' obesity risk increased by 18% per 1 oz increase in powdered formula intake. Formula intake among boys was on average 1.42 oz (in dry weight) higher than that among girls, which, in turn, mediated their increased obesity risk ($IE_{RR} = 1.27$, 95% confidence interval: 1.02, 1.90).
Conclusions: The increased obesity risk among Latino boys compared with girls at 12 mo was explained by higher rates of formula feeding at 6 and 9 mo of age. Future investigations of cultural values and beliefs in gender-related feeding practices are warranted to understand the differences in obesity risk between Latino boys and girls.

Keywords: Formula feeding, Breastfeeding, Obesity risk, Infants, Latino, Gender

Introduction

The Latino population, defined as individuals with origins in Mexico, Puerto Rico, Cuba, or other "Hispanic, Latino, or Spanish" heritages, is the fastest-growing ethnic group in the United States [1]. According to the 2019 Census Report, 18.6 million children, or 25% of all children in the United States, are Latino [2]. Children of Latino origin are disproportionately affected by the obesity epidemic, with Latino boys more likely to be categorized as overweight or obese than girls [3–5]. Other than African American girls, Latino boys maintain the highest BMI from early childhood to adolescence, putting them at higher risk for early onset of cardiometabolic morbidities [6,7].

The onset of obesity begins early among Latino children. In a longitudinal study examining obesity trends by race/ethnicity, by 2 y of age, Latino boys had a significantly higher BMI than

Abbreviations used: NDSR, nutrition data system for research; SNAP, Supplemental Nutrition Assistance Program; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.

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boys from other racial/ethnic groups, even after controlling for socioeconomic status [8]. Another prospective study found substantially higher weight, total fat mass, and waist circumference among Latino children compared with non-Latino white children, primarily because of differences in feeding practices and growth rate during infancy. Specifically, a high proportion of formula compared with breastfeeding, early introduction to solids, and rapid weight gain during infancy explained about80% of the observed differences in the higher obesity risk [9].

Practices related to milk-feeding (breast milk and/or formula) play a significant role in predicting weight gain during infancy. Because of its nutritive and nonnutritive benefits, breastfeeding (directly or expressed) is considered optimal for infants, whereas formula is recommended as an alternative when breastfeeding is contraindicated or not possible [10]. Recommendations are to breastfeed exclusively for the first 6 mo and to continue breastfeeding along with complementary feeding until 2 y of age or longer [10]. Because breastfeeding is associated with a lower likelihood of respiratory infections, sudden infant death syndrome, and improved neurodevelopment among children, increasing rates of breastfeeding among low-income and racial/ethnic minority women has been endorsed as an important strategy to reduce health care costs and address health disparities in the United States. [11,12].

Differences in infant feeding is attributed to both- biological differences by sex and socially constructed differences by gender. Because of biological differences, the daily energy requirements of male infants tend to be slightly higher compared with female infants [13]. Through the placenta, infant sex is communicated to the mammary gland prenatally via hormones and other signals. To meet the higher energy requirements of male infants, breast milk from mothers of male infants has more calories than milk from mothers of female infants [14]. In addition, male infants are likely to consume ~6% more breast milk per day than female infants [15]. However, no differences in appetite and growth-regulating factors are seen in breast milk by infant sex [16].

In addition to differences by sex, gender differences have been reported in parenting and feeding practices. For instance, among a national longitudinal sample of 2839 children participating in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Infants and Toddler Feeding Practices Study 2, girls were fed significantly more healthy foods than boys [17]. Other studies have found that controlled and pressurized feeding styles (for example, insisting on finishing the bottle or food, giving food to soothe, or adding cereal to a bottle) are more common among parents of boys than girls [18–20]. Data from the 2009–2010 Pregnancy Risk Assessment Monitoring System indicated that breastfeeding initiation was less common for Latino boys than girls, and if breastfeeding was initiated, boys were significantly less likely than girls to be breastfed for at least 2 months. [21]. The revised WIC package, designed to support continued breastfeeding, was less effective in reducing obesity risk among Latino boys than girls, which was attributed to Latino mothers switching to formula feeding earlier among boys than girls [22]. To further examine gender differences in milk-feeding practices and the relation with obesity risk, the objectives of this study were to examine breastfeeding and formula-feeding practices overall and by infant gender and to examine relations among infant gender, milk-feeding practices, and obesity risk among Latino infants over the first year of life. We hypothesized that Latino boys would be at a higher obesity risk (≥85th percentile weight-for-length) than girls at 12 mo of age and that higher rates of formula feeding among Latino boys compared with girls would mediate the higher obesity risk.

Methods

Study design and participants

This study included 90 Latino mother–infant dyads from a feeding study involving 256 mother–infant dyads from multiple racial/ethnic groups [23]. This study was approved by the Office of Research Integrity at University of North Carolina at Greensboro.

Mother–infant dyads were recruited from a local pediatric clinic mainly serving low-income families. Inclusion criteria were maternal age of ≥18 y, fluency in English or Spanish, singleton pregnancy, and gestational age of ≥37 wk. The exclusion criteria included any health issues among infants that could affect feeding practices, such as cleft palate, congenital problems, and allergic colitis. Based on the clinic's appointment schedule for well-child visits, mothers of infants aged 2 mo or younger were approached by the study staff in the waiting area to explain the study and assess their interest in participation. Upon indication of interest and confirmation of eligibility, the mothers were asked to provide written consent for themselves and written assent on behalf of their infants. Mothers were also asked to give permission to access infants' length and weight measurements from clinic records by signing the Health Insurance Portability and Accountability Act form. Trained bilingual research assistants conducted interviews by telephone in English or Spanish at 2, 4, 6, and 9 mo of infant age to collect information on breastfeeding and formula-feeding practices. Two-thirds of the interviews were conducted in Spanish. Participants received incentives after completing each interview.

Interviews and measures

At the 2-mo interview, we collected information on maternal education, marital status, household size, and participation in federal food assistance programs, such as WIC and the Supplemental Nutrition Assistance Program (SNAP). Mothers were also asked about their country of origin if they were not born in the United States. Information on parity and mode of birth delivery was also collected.

In this study, breastfeeding refers to both direct and pumped breast milk feeding. At the 2- and 4-mo interviews, breastfeeding-related questions from the Infant Feeding Practices Study II, conducted by the Food and Drug Administration and Centers for Disease Control and Prevention, were used to collect information on breastfeeding practices [24]. First, we asked: "Are you currently breastfeeding or feeding your baby pumped milk?" ("yes" or "no" response). If yes, we asked whether breastfeeding was exclusive or partial. These responses were used to group infants into 3 milk-feeding categories, namely, only formula, both formula and breast milk (mixed), or only breast milk (exclusive). Early introduction to complementary foods was assessed at the 4-mo interview by asking, "Is your baby fed any solid foods (like baby cereal, rice puffs, crackers,

mashed potato, etc.) through formula or directly?" ("Yes" or "No").

At 6 and 9 mo of age, 24-h feeding recalls were conducted to collect milk-feeding practices in detail. Recalls were conducted by telephone using the Nutrition Data System for Research (NDSR) software developed by the Nutrition Coordinating Center (University of Minnesota). Research assistants completed a 2-d NDSR training and conducted practice 24-h recalls until >95% reliability was achieved. On the day prior to the recall interview, pictures of standard sippy cups, formula bottles, and spoons were texted to help participants report portion sizes accurately. Recalls were conducted using the multiple-pass method, starting by noting the times of each feeding from midnight to midnight on the previous day.

For each feeding, detailed information on food types, amounts, and preparation steps was collected. We also recorded how much of the total food prepared was consumed by the infant. We collected information on the brand and type of formula (for example, powdered, ready-to-use, or concentrated). For powdered formula, we recorded the number of formula scoops and the amount of water (in fluid oz). After ascertaining how much formula was prepared, mothers were asked to determine what amount of prepared formula their infant consumed. Based on the specific formula information collected during recall, that is, the number of formula scoops and the amount of water added, we noted that 14% of the participants prepared formula above or below the recommended concentration of 1 scoop of formula and 2 oz of water. Hence, we estimated formula intake by total dry weight in oz. Ultimately, the recalls were used to determine frequency and amount of breast milk, formula, and complementary foods fed and average calories consumed in total and from each source at 6 and 9 mo of age.

Sociodemographic information from 2-mo interviews was organized as follows: mode of delivery: cesarean compared with vaginal; parity: multiparous compared with primiparous; maternal education: less than high school compared with high school or General Educational Development program (GED); employment status: employed (part/full-time) compared with unemployed; SNAP participation: yes compared with no; WIC participation: yes compared with no; born in the United States: yes compared with no, and if "no", country of birth was noted.

Infants' weight-for-length percentile was calculated by obtaining weight and length measurements at 12 mo (±10 d) from clinic health records. Infant weight at 2 mo was also retrieved to control for early infancy weight status. Infant weight and length were reviewed for outliers and homogeneity of variance to confirm that the mean differences were not influenced by extreme values. All measurements were within the normal range, and none were excluded. Infant weight-for-length percentiles were calculated using age- and sex-specific WHO growth charts [25]. Infants were grouped as normal (<85th percentile) or at risk for obesity (≥85th percentile). Two infants were below the 5th weight-for-length percentile; however, sensitivity analyses showed the results did not substantively differ with their inclusion/exclusion. Therefore, results are presented with the full sample included.

Statistical analyses

The analyses followed a prespecified statistical plan and were performed using R (version 4.2.1, R Core Team, 2023). Descriptive statistics were used to examine sociodemographic characteristics, breastfeeding prevalence, and obesity risk among infants. Bivariate chi-square tests for categorical variables and analysis of variance for continuous variables were used to examine differences in obesity risk and feeding practices by infant gender. Mediation analysis was conducted to test the associations between infant gender, daily formula consumption, and obesity risk. The formula amounts from the 6- and 9-mo recalls were averaged to obtain a more reliable measure of infant feeding patterns compared with using a single observation. Mediation analysis was conducted using a regression-based approach and by applying the resampling methods described by MacKinnon et al. [26]. For each bootstrapped sample, the direct effect of the exposure variable on the proposed mediator (path a, formula intake regressed on infant gender) was multiplied by the direct effect of the proposed mediator, controlling for the exposure variable, on the outcome variable of interest (path b, obesity risk regressed on formula intake). This method is also referred to as the "product of coefficients" approach.

The outcome of interest for the indirect effect was binary (<85th weight-for-length percentile compared with ≥85th weight-for-length percentile) rather than continuous, as in traditional mediation analyses. Therefore, we used linear regression methods to estimate a continuous mediator (formula intake in oz) and logistic or log-linear regression methods to calculate infant weight-for-length <85th percentile compared with ≥85th percentile. The association between infant gender and average formula intake (path a) was estimated using Tobit regression (R package vector generalized linear and additive models) to accommodate the censoring of the dependent variable at 0. Poisson regression with robust standard errors was used to estimate the association between formula intake and relative risk of obesity risk (path b) while controlling for infant gender. Robust standard errors were calculated using a sandwich estimator implemented in the R package, *sandwich*. The indirect effect of infant gender on obesity risk, transmitted through average formula intake (IE_{RR}), was calculated by multiplying the coefficients for path a and path b and exponentiating the product to put in terms of relative risk. The confidence intervals (CIs) for paths a and b and the IE_{RR} were calculated using bootstrapping with 10,000 replications. Statistical significance was inferred if bootstrapped CI_{95} did not contain 0 for estimates drawn from the Tobit regression model (path a) and did not contain 1.00 in the relative risk estimates drawn from the Poisson regression model (path b) and for estimates of indirect effects (IE_{RR}). The covariates adjusted in all models included infant weight at 2 mo (first observation), mode of delivery, parity, maternal education, and employment status. Infant weight at 2 mo was grand mean-centered to improve interpretability of regression coefficients. All other coefficients were dichotomous and dummy coded. Statistical significance was deemed marginal at $P < 0.10$ and significant at $P < 0.05$.

Results

The average age of mothers was 30 y, and the reported monthly household income was ~$1800, with an average household size of 5 individuals (Table 1). Most mothers were married (68%), and 49% reported having a high school

TABLE 1
Description of sociodemographic characteristics of Latino mother–infant dyads ($n = 90$)

Characteristics	n (%)
Infant sex—male	44 (49)
Maternal characteristics	
Married	61 (68)
Less than high school	34 (38)
High school/GED	44 (49)
Unemployed	74 (81)
WIC receipt	70 (78)
SNAP receipt	17 (19)
Non-United States born	72 (80)
Birth country[1]	
Mexico	45 (62)
El Salvador	10 (14)
Honduras	7 (10)
Guatemala	6 (8)
Others (Costa Rica, Cuba)	5 (6)
	Mean (SD)
Duration in United States[1] (y)	10 (7)
Maternal age (y)	30 (5)
Household income[2] ($, monthly)	1801 (1043)
Household size (individuals)	5 (1)

Abbreviations: GED, General Educational Development program; SNAP, Supplemental Nutrition Assistance Program; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.
[1] Of mothers born outside the United States (73/90 participants)
[2] income sample size = 86 (remaining 14 reported either "don't know" or "refused to provide information").

education. Working full or part time was uncommon; 81% of mothers were unemployed. Over three-quarters of mothers were participating in WIC, whereas only 19% participated in SNAP. Eighty percent of the mothers were born outside the United States, mainly in Mexico, and had lived in the Unites States for an average of 10 y (Table 1). At 6 and 9 mo of infant's age, 4% and 5% used a breast pump and were feeding pumped milk to the infant, respectively.

We found that 66% and 55% of mothers fed their infants both formula and breast milk (mixed feeding) at 2 and 4 mo, respectively (Table 2). There was no difference in milk-feeding patterns between boys and girls at 2 and 4 mo of age. Early introduction to solids was reported by 8% of the participants, with no significant differences between boys and girls. At 6 mo, 44% and at 9 mo, 50% of the mothers were feeding formula along with complementary foods (Table 2). In comparison, formula feeding rates were higher for boys than girls at 6 ($P = 0.053$) and 9 mo ($P = 0.009$) of age. Table 2 also shows that over one-third of infants were at risk for obesity (≥85th percentile weight-for-length) at 12 mo of age.

At 6 and 9 mo of age, the numbers of daily formula feedings were significantly higher, and breastfeeding frequency was significantly lower in boys compared with girls (Table 3). At both 6 and 9 mo, boys consumed significantly more calories from formula than girls (6 mo: $F_{(1,89)} = 11.43$, $P = 0.001$; 9 mo: $F_{(1,89)} = 8.16$, $P = 0.005$). No significant difference in calories from complementary foods was seen at either 6 mo ($F_{(1,89)} = 1.36$; $P = 0.245$) or 9 mo of age ($F_{(1,85)} = 0.21$, $P = 0.641$, Table 3).

TABLE 2
Description of milk-feeding practices and obesity risk overall and by gender among Latino infants ($n = 90$)

	Overall ($n = 90$)	Boys ($n = 44$)	Girls ($n = 46$)	P[1]
	n (%)	n (%)		
Early infancy[2]				
2 mo				
Only formula	14 (15)	8 (17)	6 (14)	
Both—formula and breast milk	59 (66)	30 (68)	29 (64)	
Only breast milk (exclusive)	17 (19)	8 (15)	9 (22)	0.93
4 mo				
Only formula	24 (27)	16 (35)	8 (18)	
Both—formula and breast milk	50 (55)	23 (50)	27 (61)	
Only breast milk (exclusive)	16 (18)	7 (15)	9 (21)	2.16
Introduction to solids ≤4 mo	7 (8)	3 (7)	4 (9)	0.54
Late infancy (along with complementary foods)[3]				
6 mo				
Formula	40 (44)	25 (57)	15 (33)	
Both—formula and breast milk	27 (30)	12 (27)	15 (33)	
Breast milk	23 (26)	7 (16)	16 (34)	5.89*
9 mo				
Formula	47 (50)	30 (65)	17 (39)	
Both—formula and breast milk	22 (26)	10 (22)	12 (27)	
Breast milk	21 (24)	6 (13)	15 (34)	9.62**
Obesity risk prevalence[4]	33 (38)	19 (43)	15 (33)	1.07

*$P = 0.053$
**$P = 0.009$.
[1] Pearson chi-square
[2] at 2 and 4 mo of noncomplementary feeding phase, only breast milk refers to exclusive breastfeeding, and no other solids or other liquids are given;
[3] during the complementary feeding phase, when solid and other liquid foods are offered, 3 categories refer to whether only formula or both formula and breast milk or only breast milk was the milk-feeding source along with other solid and liquid foods
[4] ≥85th percentile weight-for-length at 12 mo.

TABLE 3
Differences in daily breastfeeding vs. formula feeding frequency and calorie intake between Latino boys and girls at 6 and 9 mo of age ($n = 90$)

	6 mo[1]			9 mo[1]		
	Boys	Girls	P^2	Boys	Girls	P^2
	Mean ± SD[3]			Mean ± SD[3]		
No. of formula feeds	4 ± 3	3 ± 2	0.026	3 ± 2	2 ± 2	0.005
No. of breastfeeds	2 ± 3	4 ± 3	0.008	1 ± 2	2 ± 3	0.002
Amount of formula fed (in oz)[4]	3 ± 3	2 ± 2	0.004	3 ± 2	2 ± 2	0.009
Formula calories (kcal)	502 ± 402	263 ± 265	0.001	449 ± 292	265 ±303	0.005
Breast milk calories (kcal)	169 ± 216	272 ± 220	0.027	103 ± 169	230 ± 200	0.001
Complementary foods calories (kcal)[5]	90 ± 154	60 ± 84	0.245	295 ± 202	274 ±184	0.641

[1] Of the total sample size 90, boys, $n = 44$ and girls, $n = 46$;
[2] analysis of variance;
[3] numbers represent average daily intake;
[4] dry weight of powdered formula in oz;
[5] anything other than milk-feeding of breast milk and/or formula.

There was a significant difference in the mean amount of formula intake between boys and girls after controlling for covariates (path a, Table 4A). Specifically, formula intake among boys was an average of 1.42 oz (in dry weight) higher than among girls. Additionally, the relative risk of obesity among infants increased by 18% per 1 oz increase in powdered formula intake (path b, Table 4B). Based on the products of path a and path b estimates, in concert with bootstrapped confidence intervals, formula intake mediated increased obesity risk among boys compared with girls at 12 mo ($IE_{RR} = 1.27$, CI_{95}: 1.02, 1.90; Figure 1).

Discussion

Our study had 3 primary findings. First, in the first 5 mo of infancy, mixed feeding of both formula and breast milk was common among Latino families. Second, at 6 and 9 mo of age, Latino boys received more formula than girls. Finally, higher formula intake among boys mediated their greater obesity risk compared with girls.

Among the Latino population, mixed milk-feeding, often referred to as las dos cosas, is more common than exclusive breastfeeding [27]. Although breastfeeding initiation is high, exclusive breastfeeding rates are significantly lower among Latino compared with non-Latino white mothers [28]. In our study, more than half of the mothers were engaging in mixed feeding practices at 2 and 4 mo of infant's age. Evidence suggest that Latino families consider mixed feeding to be ideal because they perceive that formula promotes infant growth by ensuring that infants receive sufficient nutrition and energy to grow, whereas breastfeeding is viewed as more beneficial from a nurturing rather than a nutritional perspective [29,30]. Acculturation may be another explanation for preferring mixed feeding over exclusive breastfeeding. In our study, 80% of the

TABLE 4
Inter-relationship between gender, average daily formula fed, and obesity risk among Latino infants ($n = 90$)

(A) Path a: examination of the association between infant gender and average daily formula fed between 6 and 9 mo among Latino infants ($n = 90$)

	β	SE	CI_{95}	P^1
Infant gender—boy	1.42	0.57	0.30, 2.54	0.01
Infant 2-mo weight (kg)	0.66	0.41	–0.14, 1.45	0.11
Mode of delivery	–0.39	0.74	–1.85, 1.06	0.59
Parity	0.18	0.61	–1.03, 1.38	0.77
Education	0.23	0.58	–0.91, 1.38	0.69
Employment	0.89	0.63	–0.35, 2.13	0.16

(B) Path b: examination of the association between average daily formula intake between 6 and 9 mo and obesity risk among Latino infants ($n = 90$)

	RR	SE	CI_{95}	P^2
Infant gender—boy	0.70	0.18	0.39, 1.25	0.23
Average daily formula intake (in oz)	1.18	0.07	1.03, 1.34	0.01
Infant 2-mo weight (kg)	1.94	0.65	1.15, 3.27	0.01
Mode of delivery	0.53	0.17	0.31, 0.93	0.03
Parity	1.63	0.46	0.80, 3.36	0.18
Education	0.71	0.03	0.32, 1.56	0.39
Employment	0.56	0.40	0.25, 1.28	0.17

Abbreviation: RR, Relative Risk.
Other variables tested in the paths a and b are infant gender: girl (0) vs. boy (1); mode of delivery: cesarean (0) vs. vaginal (1); parity: multiparous (0) vs. primiparous (1); maternal education: less than high school (0) vs. high school or more (1); employment: not working (0) vs. working part/full time (1). Infant weight at 2 mo was mean centered. In path b, average daily intake of formula (dry weight in oz) was mean centered as well.
[1] Tobit regression with the dependent variable: average daily intake formula in dry weight (in oz). Formula intake from 6- to 9-mo recalls was averaged;
[2] Poisson regression with the dependent variable: no obesity risk <85th percentile (0) vs. obesity risk ≥85th weight-for-length percentile (1).

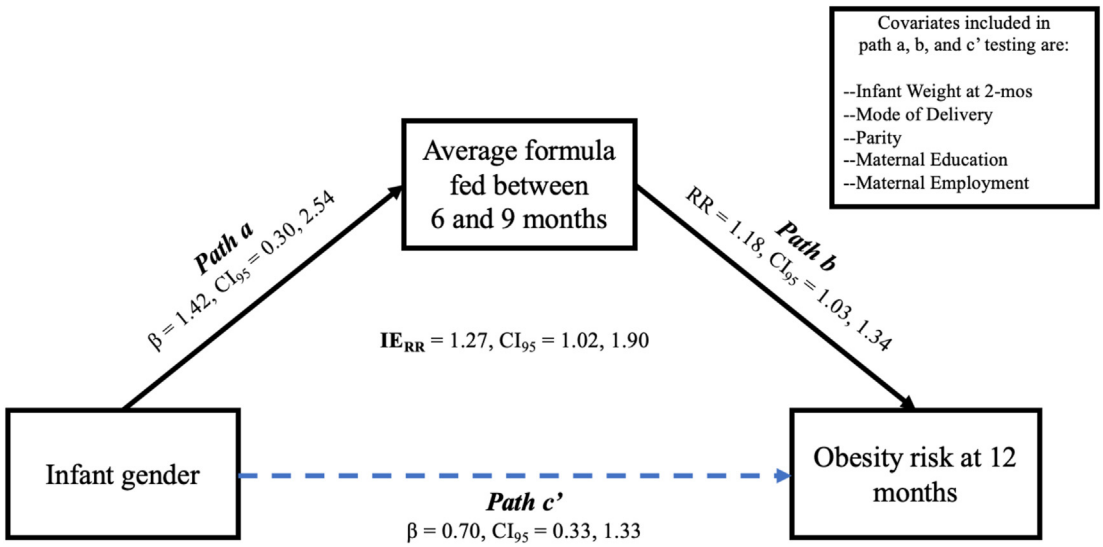

FIGURE 1. Mediation of relations among infant gender, amount of formula fed, and obesity risk at 12 mo.

mothers were immigrants and had been living in the United States for an average of 10 y. Acculturation influences feeding practices with longer residence in the United States associated with mixed feeding [31]. In a review of feeding practices among African immigrant mothers, along with acculturation, easy access to formula and a desire for babies to gain weight quickly were significant motivators for introducing formula while continuing to breastfeed [32]. Poverty and related stressors may also affect breastfeeding practices among Latinos populations in the United States. In interviews with 100 Latino mothers living in the United States, Gross et al. [33] found that food insecurity, including high-stress levels owing to financial instability, immigration issues, and poor support, significantly reduced breastfeeding self-efficacy. Formula feeding was often preferred by mothers because it ensured that their babies were getting all the "important" nutrients. In contrast, breastfeeding mothers were unsure whether they were producing enough milk and did not want to "pass their stress" to babies through milk.

In general, formula-fed infants are expected to gain more weight than breastfed infants, mainly attributed to higher protein content in formula compared with breast milk [34]. However, in our study, as in other studies, formula-fed infants had a higher obesity risk. In a study with 2553 mother–infant dyads, the formula-fed group had the highest BMI *z* scores at 12 mo compared with infants who were breastfed directly or given expressed breast milk by bottle [35]. Similarly, in a 3-group study comparing infants who were fed only breast milk, a low volume (<28 fluid oz/d) of formula, or a high volume (≥28 fluid oz/d) of formula, infants in the high-volume group were twice as likely to experience obesity risk than infants in the breast milk only group [36]. Specific behaviors associated with formula feeding, such as making concentrated formula, adding cereal to the formula bottle, and putting the infant in bed with a formula bottle, are shown to increase the risk of overfeeding [37]. The formula also contributes significantly to daily added sugar intake among infants. Formula-fed infants consume nearly twice the energy from added sugar intake, which, in turn, significantly increases the risk for rapid weight gain [38].

Our study, showing that Latino girls are more likely to be continued on breast milk than boys, suggests that differences in obesity risk are at least in part because of gender compared with biological differences by infant sex. Most of the mothers in our sample were born in Mexico or other Latin countries. Even after migration and several years of acculturation, ethnic origin and related traditional norms often remain important factors in predicting food parenting and views on gender roles [39]. In Latin American and other low- and middle-income countries infant gender plays a significant role in predicting milk-feeding practices. For instance, indigenous mothers in Guatemala reported believing that boys were hungrier compared with girls and were less satisfied with breastfeeding alone. This belief was reflected in their feeding practices, and mixed feeding and the early introduction of solids were more common in boys than in girls [40]. Reviews on gender differences in nutritional status in Latin America, Asia, and Africa have noted that social norms related to inheritance and the economic returns of sons compared with daughters influence parenting and feeding practices, such as breastfeeding initiation and duration; food distribution and meal portioning; and use of medical services [41–43].

We found no gender-related differences in calories from complementary foods among infants in our study. However, boys consumed significantly higher amounts of formula compared with girls between 6 and 9 mo of age, which, in turn, mediated increased obesity risk. This finding warrants qualitative investigation to understand how traditional norms and beliefs affect feeding practices and potential linkages to gender-based differences in obesity risk among Latino children. Based on the cultural norm of "machismo" (the Latino belief that males are more powerful than females), Latino boys may be expected to be stronger and bigger than girls. Resultant alterations in parenting have been postulated to explain differences in obesity and related risks between Latino boys and girls [44,45]. This norm might also be rooted in infant feeding practices, with mothers who endorse machismo becoming *machistas* by providing more formula to boys than girls to increase boys' strength and power.

Our study has limitations that should be considered. We conducted only one 24-h recall at each time point during the complementary feeding phase compared with multiple recalls to capture variability in daily intake. Second, between 0 and 5 mo,

overall milk-feeding status (exclusive breastfeeding compared with mixed compared with formula) was compared. Conducting 24-h recalls during this period and comparing differences in breast milk and formula frequencies and amounts would have improved precision in understanding whether, within mixed feeding, boys received more formula than girls during this period. Third, our study recruited participants from a single mid-size clinic, which limits the generalizability of our results. Fourth, we did not explore differences in milk-feeding practices by country of origin and acculturation status because of our small sample size. Further, lack of qualitative investigation on gender-related beliefs and comparison of reasons for continuation or discontinuation of breastfeeding limits the interpretation of our findings. In the future, a larger longitudinal study among Latino families in the United States is warranted to better understand relations among acculturation, sociocultural norms by country of origin, and milk-feeding practices from early to late infancy between boys and girls. Further, in-depth investigations of cultural values and beliefs related to gender roles and their impact on parenting and feeding practices are warranted to understand differences in obesity risk between Latino boys and girls. Overall, obesity prevention efforts are critical to reduce the disproportionate burden of excess weight gain and related comorbidities among young Latino children, the fastest-growing population group in the United States.

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Author contributions

All authors read and approved the final manuscript.

Conflict of interest

The authors report no conflicts of interest.

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References

[1] A. Mosaic, Not a Monolith: A Profile of the U.S. Latino Population, 2000–2020. Latino Policy & Politics Institute [Internet]. Published October 26, 2022 [cited April 26, 2023]. Available from: https://latino.ucla.edu/research/latino-population-2000-2020/.

[2] Latino Children Represent Over a Quarter of the Child Population Nationwide and Make Up at Least 40 Percent in 5 Southwestern States. Hispanic Research Center [Internet] [cited April 26, 2023]. Available from: https://www.hispanicresearchcenter.org/.

[3] C.L. Ogden, C.D. Fryar, C.B. Martin, D.S. Freedman, M.D. Carroll, Q. Gu, et al., Trends in obesity prevalence by race and Hispanic origin-1999–2000 to 2017–2018, JAMA 324 (12) (2020) 1208–1210.

[4] Robert Wood Johnson Foundation. State of Childhood Obesity – New Data Compares Latest Child Obesity Rates By Age, Gender, and Race [Internet]. Published January 14 2020 [cited August 15, 2023]. Available from: https://stateofchildhoodobesity.org/new-data-compares-latest-child-obesity-rates-by-age-gender-and-race/.

[5] E. Lawrence, S. Mollborn, F. Riosmena, Early childhood disadvantage for sons of Mexican immigrants: body mass index across ages 2–5, Am. J. Health Promot. 30 (7) (2016) 545–553.

[6] G.C. Liu, T. Hannon, R. Qi, S.M. Downs, D.G. Marrero, The obesity epidemic in children: Latino children are disproportionately affected at younger ages, Int. J. Pediatr. Adolesc. Med. 2 (1) (2015) 12–18.

[7] C.R. Isasi, C.M. Parrinello, G.X. Ayala, A.M. Delamater, K.M. Perreira, M.L. Daviglus, et al., Sex differences in cardiometabolic risk factors among Hispanic/Latino youth, J. Pediatr. 176 (2016) 121–127.e1.

[8] J. Min, X. Wen, H. Xue, Y. Wang, Ethnic disparities in childhood BMI trajectories and obesity and potential causes among 29,250 US children: findings from the Early Childhood Longitudinal Study-Birth and Kindergarten Cohorts, Int. J. Obes. (Lond). 42 (9) (2018) 1661–1670.

[9] E.M. Taveras, M.W. Gillman, K.P. Kleinman, J.W. Rich-Edwards, S.L. Rifas-Shiman, Reducing racial/ethnic disparities in childhood obesity: the role of early life risk factors, JAMA Pediatr 167 (8) (2013) 731–738.

[10] U.S. Department of Agriculture and U.S. Department of Health and Human Services, Dietary Guidelines for Americans, 2020–2025, 9th ed., December 2020 [date updated; date cited]. Available from: DietaryGuidelines.gov. (Accessed 10 December 2023).

[11] U.S. Department of Health and Human Services. CDC. CDC's work to support and promote breastfeeding in hospitals, worksites, and communities [Internet] [cited January 18, 2024]. Available from: https://www.cdc.gov/breastfeeding/pdf/breastfeeding-cdcs-work-508.pdf.

[12] R. Pérez-Escamilla, What will it take to improve breastfeeding outcomes in the United States without leaving anyone behind? Am. J. Public Health. 112 (S8) (2022) S766–S769.

[13] S.V. Stan, D. Grathwohl, L.M. O'Neill, J.M. Saavedra, N.F. Butte, S.S. Cohen, Estimated energy requirements of infants and young children up to 24 months of age, Curr. Dev. Nutr. 5 (11) (2021) nzab122.

[14] A. Bzikowska-Jura, P. Sobieraj, D. Szostak-Węgierek, A. Wesołowska, Impact of infant and maternal factors on energy and macronutrient composition of human milk, Nutrients 12 (9) (2020) 2591.

[15] T.H. da Costa, H. Haisma, J.C. Wells, A.P. Mander, R.G. Whitehead, L.J. Bluck, How much human milk do infants consume? Data from 12 countries using a standardized stable isotope methodology, J. Nutr. 140 (12) (2010) 2227–2232.

[16] E.K. Eckart, J.D. Peck, E.O. Kharbanda, E.M. Nagel, D.A. Fields, E.W. Demerath, Infant sex differences in human milk intake and composition from 1- to 3-month post-delivery in a healthy United States cohort, Ann Hum Biol 48 (6) (2021) 455–465.

[17] M.P. Chaparro, C.E. Anderson, Differences in early childhood dietary behaviors by infant feeding type and sex, J. Nutr. 151 (7) (2021) 2001–2009.

[18] A.V. Hyczko, C.F. Ruggiero, E.E. Hohman, S. Anzman-Frasca, J.S. Savage, L.L. Birch, et al., Sex differences in maternal restrictive feeding practices in the intervention nurses start infants growing on healthy trajectories study, Acad. Pediatr. 21 (6) (2021) 1070–1076.

[19] J.K. Orrell-Valente, L.G. Hill, W.A. Brechwald, K.A. Dodge, G.S. Pettit, J.E. Bates, "Just three more bites": an observational analysis of parents' socialization of children's eating at mealtime, Appetite 48 (1) (2007) 37–45.

[20] A. Brown, H. Rowan, Maternal and infant factors associated with reasons for introducing solid foods, Matern. Child Nutr. 12 (3) (2016) 500–515, https://doi.org/10.1111/mcn.12166.

[21] E.F. Shafer, S.S. Hawkins, The impact of sex of child on breastfeeding in the United States, Matern, Child Health J 21 (11) (2017) 2114–2121.

[22] M.P. Chaparro, C.E. Anderson, C.M. Crespi, S.E. Whaley, M.C. Wang, The effect of the 2009 WIC food package change on childhood obesity varies by gender and initial weight status in Los Angeles County, Pediatr Obes 14 (9) (2019) e12526.

[23] J.M. Dharod, C.M. Frazier, J. Labban, M.M. Black, Breastfeeding duration and associations with prevention of accelerated growth among infants from low-income, racially and ethnically diverse backgrounds, Public Health Nutr 27 (1) (2024) e6.

[24] S.B. Fein, J. Labiner-Wolfe, K.R. Shealy, R. Li, J. Chen, L.M. Grummer-Strawn, Infant feeding practices study II: study methods, Pediatrics 122 (Suppl 2) (2008) S28–S35.

[25] WHO Child Growth Standards. Growth velocity based on weight, length and head circumference. Methods and development [Internet] [cited June 2023]. Available from: https://www.who.int/tools/child-growth-standards/standards/length-height-for-age.

[26] D.P. Mackinnon, C.M. Lockwood, J. Williams, Confidence limits for the indirect effect: distribution of the product and resampling methods, Multivariate Behav. Res. 39 (1) (2004) 99.
[27] A.M. Linares, D. Cartagena, M.K. Rayens, Las dos cosas versus exclusive breastfeeding: a culturally and linguistically exploratory intervention study in Hispanic mothers living in Kentucky, J. Pediatr. Health Care. 33 (6) (2019) e46–e56.
[28] CDC, Breastfeeding Report Card United States, 2020 [Internet] [cited January 28, 2021]. Available from: https://www.cdc.gov/breastfeeding/data/reportcard.htm.
[29] M. Bartick, C. Reyes, Las dos cosas: an analysis of attitudes of Latina women on non-exclusive breastfeeding, Breastfeed Med 7 (1) (2012) 19–24.
[30] R.E. Chatham, S.J. Mixer, Cultural influences on childhood obesity in ethnic minorities: a qualitative systematic review, J. Transcult. Nurs. 31 (1) (2020) 87–99.
[31] A. Rosenthal, S.B. Oliveira, U. Madubuko, H. Tanuos, J. Schwab, I.M. Monteiro, Effects of immigration on infant feeding practices in an inner city, low socioeconomic community, J. Natl Med. Assoc. 111 (2) (2019) 153–157.
[32] A.O. Odeniyi, N. Embleton, L. Ngongalah, W. Akor, J. Rankin, Breastfeeding beliefs and experiences of African immigrant mothers in high-income countries: a systematic review, Matern. Child Nutr. 16 (3) (2020) e12970, https://doi.org/10.1111/mcn.12970.
[33] S. Gross, A.L. Mendelsohn, M.M. Arana, M.J. Messito, Food insecurity during pregnancy and breastfeeding by low-income Hispanic mothers, Pediatrics 143 (6) (2019) e20184113.
[34] K. Dewey, L. Bazzano, T. Davis, S. Donovan, E. Taveras, R. Kleinman, et al., The duration, frequency, and volume of exclusive human milk and/or infant formula consumption and overweight and obesity: a systematic review, USDA Nutrition Evidence Systematic Review, Alexandria, VA, 2020.
[35] M.B. Azad, L. Vehling, D. Chan, A. Klopp, N.C. Nickel, J.M. McGavock, et al., Infant feeding and weight gain: separating breast milk from breastfeeding and formula from food, Pediatrics 142 (4) (2018) e20181092.
[36] J. Huang, Z. Zhang, Y. Wu, Y. Wang, J. Wang, L. Zhou, et al., Early feeding of larger volumes of formula milk is associated with greater body weight or overweight in later infancy, Nutr. J. 17 (1) (2018) 12.
[37] J. Appleton, C.G. Russell, R. Laws, C. Fowler, K. Campbell, E. Denney-Wilson, Infant formula feeding practices associated with rapid weight gain: a systematic review, Matern. Child Nutr. 14 (3) (2018) e12602.
[38] K.L. Kong, B. Burgess, K.S. Morris, T. Re, H.R. Hull, D.K. Sullivan, et al., Association between added sugars from infant formulas and rapid weight gain in US infants and toddlers, J. Nutr. 151 (6) (2021) 1572–1580.
[39] J.N. Gomel, A. Zamora, English- and Spanish-speaking Latina mothers' beliefs about food, health, and mothering, J. Immigr. Minor Health 9 (4) (2007) 359–367.
[40] A. Tumilowicz, J.P. Habicht, G. Pelto, D.L. Pelletier, Gender perceptions predict sex differences in growth patterns of indigenous Guatemalan infants and young children, Am. J. Clin. Nutr. 102 (5) (2015) 1249–1258.
[41] A.L. Thompson, Greater male vulnerability to stunting? Evaluating sex differences in growth, pathways and biocultural mechanisms, Ann. Hum. Biol. 48 (6) (2021) 466–473.
[42] S. Thurstans, C. Opondo, A. Seal, J. Wells, T. Khara, C. Dolan, et al., Boys are more likely to be undernourished than girls: a systematic review and meta-analysis of sex differences in undernutrition, BMJ Glob. Health. 5 (12) (2020) e004030.
[43] J.C. Costa, I.C.M. da Silva, C.G. Victora, Gender bias in under-five mortality in low/middle-income countries, BMJ Glob. Health. 2 (2) (2017) e000350, https://doi.org/10.1136/bmjgh-2017-000350.
[44] A.M. Cheney, T. Nieri, E. Davis, J. Prologo, E. Valencia, A.T. Anderson, et al., The sociocultural factors underlying Latina mothers' infant feeding practices, Glob. Qual. Nurs. Res. 6 (2019) 2333393618825253.
[45] M. Aceves-Martins, E. Llauradó, L. Tarro, R. Solà, M. Giralt, Obesity-promoting factors in Mexican children and adolescents: challenges and opportunities, Glob. Health Action. 9 (2016) 29625.