Longitudinal Associations between Dietary Patterns and Weight Status in Puerto Rican Infants and Toddlers' Participants of the WIC Program

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Objective: To explore the associations between feeding practices and diet quality with weight in Puerto Rican infants/toddlers.

Methods: This was a longitudinal study done in a sample of 296 caregivers and their children aged 0-24 months from a WIC clinic in PR. A. Caregivers completed questionnaires on socio-demographics and feeding practices and infant's weight and length were measured at the baseline and follow-up (1 year later) visits. Diet quality was assessed using an adapted version of the Diet Quality Index Score (DQIS) for infants/toddlers.

Results: A total of 77 participants completed the follow-up visit. At baseline, overweight/obesity was found in 5% while in the follow-up visit it increased to 16%. Exclusive breastfeeding for less than one month (RR 1.32, 95% C.I. 1.10, 1.59) and formula-based diets (RR 1.29; 95% C.I. 1.08, 1.54) increased the odds of overweight/obesity at follow-up compared to longer breastfeeding and those never formula-fed. DQIS significantly decreased from the baseline to the follow-up visit. The overall DQIS was not significantly associated with weight; however, a trend was observed between a negative change in the breast-milk and 100% juices score with higher odds of overweight/obesity while a negative change in the vegetable score was associated with lower odds of overweight/obesity.

Conclusion: Diet quality significantly decreased over time in our sample. Breastfeeding for less than one month and formula-based diets significantly increased the odds of overweight/obesity at follow-up, but no significant associations were found with DQIS or its components. [*P R Health Sci J 2019;38:75-80*]

Key words: Infants, Dietary patterns, Diet quality, Obesity, Hispanic

From the moment of conception to the first two years of life, nutrition plays a major role in the prevention of obesity and chronic diseases throughout life (1,2). Unfortunately, in the last few decades, the prevalence of infant obesity has increased globally (3). As estimated by the World Health Organization (WHO) in 2015, this issue is affecting more than 42 million children under the age of five worldwide (4). In the US, 8.4% of children between the ages of two and five years old are obese (5). Among infants, the prevalence of overweight and obesity is 8.1% (6) and among young children participating in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) program, this is even higher (16.1%) (7). This is a public health problem as obesity early in life increases the risk of excessive weight in childhood and developing chronic diseases in adulthood, particularly if the rapid weight gain occurs during the first months of life due to the metabolic programming occurring at this stage (8,9).

Childhood obesity is a multi-factorial problem related to inadequate breastfeeding practices, early introduction of complementary foods, low diet quality, lack of physical activity, sedentary lifestyle, inadequate sleep duration, among others (8,10). However, there are limited studies among infants and toddlers, particularly in Hispanics, a group with large health disparities and high burden of obesity and other chronic diseases (11). For instance, Hispanic infants have a higher prevalence

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of obesity (14.1%) than other groups (Blacks 8.7% and Whites 8.4%) (6). In addition, compared to Whites, Hispanics experience rapid weight gain in infancy, which has been associated with certain feeding practices, such as nonexclusive breastfeeding and early introduction of solid foods (12). More longitudinal studies are needed to help understand the factors contributing to excessive weight gain in Hispanics participants of the WIC program in order to design evidenced-based preventive interventions within WIC for this group. Therefore, the present study explored the longitudinal associations of feeding practices (breastfeeding and complementary feeding) and diet quality with weight status in a sample of infants and toddlers' participants of the WIC program in Puerto Rico.

Methods

Study design

This was a longitudinal study in a sample of infants and toddlers' participants of the WIC program in Puerto Rico. The initial visit was conducted among 296 caregivers and their infants and toddlers aged 0-24 months. The follow-up visit was conducted among those who consented to participate in future studies (n=213) at around one year later, when children were 11-36 months old. In both visits, caregivers completed questionnaires on socio-demographics, breastfeeding and complementary feeding practices, and infant dietary patterns. In addition, infant's weight and length were measured. This study was approved by the Institutional Review Board of the Medical Sciences Campus at the University of Puerto Rico, and all participants provided written informed consent.

Subjects

We recruited caregivers with singleton infants and toddlers, aged 21 years or older, and who were participants of the WIC clinic located in the municipality of Trujillo Alto, from November 2014 to February 2015. We excluded infants and toddlers with major anomalies and disabilities that could impede regular feeding practices.

Socio-demographic questionnaire

Caregivers completed a short self-administered socio-demographic questionnaire, with information about their age, sex, relationship with the infant, education, number of children, number of people living in the household, the child's gender, age, among others.

Anthropometric measurements

Trained research staff measured infants' weight (kg) using a scale for infants and toddlers, while they were wearing light clothes, clean diaper, and no shoes and length (cm) using an infantometer. Both measurements were taken in duplicates and averaged. Weight status was assessed using the WHO weight-for-length z-scores growth charts, which are age- and sex- specific (13).

Infants and toddlers' weight status was classified as follows: underweight as a weight-for-length z-score ≤-2 standard deviations, healthy as a weight-for-length z-score above -2 and below +1 standard deviations, risk of overweight as a weight-for-length z-score between +1 and below +2 standard deviations, and overweight or obesity as a weight-for-length z-score ≥+2 standard deviations (13).

Breastfeeding and Complementary Feeding Questionnaire

Caregivers completed an interviewer-administered questionnaire that collected data on breastfeeding and complementary feeding practices. This questionnaire particularly addressed initiation of breastfeeding, duration of breastfeeding (partial or exclusively), timing of introduction of infant formula, cow's milk or any other milk, water, juice, and solid food.

Infant Food Frequency Questionnaire (FFQ)

We used a validated infant semi-quantitative FFQ to assess infants and toddlers' food intake (14). Briefly, this infant FFQ was composed of 52 food items, with information on how these were prepared, their source (i.e. baby food, canned, fresh) and serving sizes in the preceding seven days. The frequency of consumption of each food was assessed as feedings per day if the food was consumed on a daily basis or times per week if it was consumed less often. Trained research personnel administered the FFQ to caregivers by face-to-face interview. A photographic booklet was created to aid caregivers estimate the portion sizes with pictures of different sizes of cups, spoons, jars of baby food, sippy cups and baby bottles and of different foods included such as cereals, cookies and other foods specially designed for babies. For the follow-up visit, this infant FFQ was adapted to include other foods commonly consumed by toddler's aged 24-36 months and larger serving sizes.

Diet Quality Index Score (DQIS) for infants and toddlers

The Diet Quality Index Score (DQIS) for infants and toddlers was used to assess diet quality in infants and toddlers based on the infant FFQ, as published previously (15). This score was designed to evaluate diet for three different age groups: 0-5 months, 8-11 months, and 12-36 months, as previously reported. Participants aged 6-7 months were excluded, as this is a period of introduction of solids and other beverages, making it difficult to assess dietary patterns. Briefly, for infants aged 0-5 months, we included nine components: milk (breast-milk or formula), cereals or grains (whole or refined grains), proteins (meat or beans), vegetables, fruits, 100% juices, sugar-sweetened beverages, sweets, and salty snacks. For all the components, except for milk, a score of 5 was assigned if the food was not introduced and a score of 0 was assigned if the food was introduced. For the milk group, 15 points were assigned if the infant was exclusively breastfed, 10 points if the infant was partially breastfed or 5 points if the infant was exclusively formula fed. For infants aged 8-11 months, the

score included the same nine components but based on the recommended portions of WIC (16), WHO (17) and the Child and Adult Care Food Program Proposed Meal Pattern (18). We used an adapted version (see supplementary material for the scores). The scores were as follows: 5 points if intake was within recommended amounts; 2.5 points if intake was slightly over the recommended amount; or 0 points if it was not consumed and/or intake was excessive. If breastfeeding exclusively, 15 extra points were added and for partial breastfeeding, 5 extra points were added. For toddlers aged 12-36 months, we used a similar scoring system as for infants aged 8-11 months, but we adjusted the portion sizes using the same guidelines and the 2015-2020 Dietary Guidelines for Americans (19). For each age group, the individual components scores were summed, and a total score was obtained ranging from 0 to 55 points (5 to 55 for infants 0-5 months and 0 to 55 for infants and toddlers 8-36 months).

Statistical analysis

Normality of the sample in this study was assessed with the Shapiro-Wilk test. Weight-for-length z-scores were not normally distributed; therefore, non-parametric tests were used. For descriptive statistics, we used median and percentiles (25th and 75th) and frequency (%). To explore the association between dietary practices and DQIS with weight-for-length z-scores, we used various tests. Mann-Whitney U-test was used to compare weight-for-length z-score at follow-up by feeding practices. Chi-square tests were conducted to examine the bivariate association between weight-for-length z-score at follow-up (<1 z-score, ≥1 z-score) and possible confounders to adjust in the final model: infant's sex (boy, girl) and age (11-23 mo., 24-36 mo.), and parental age (<30 y, ≥30 y), BMI (healthy, overweight/obese), education (≤high school, >high school), or perception of infant's weight (healthy, overweight/obese). Wilcoxon signed-rank test was used to compare baseline and follow-up changes in total diet quality score and its individual components. Finally, a log-binomial regression model was used to examine the relative risk (RR) for weight-for-length z-score at follow-up (≥ 1 z-score vs. <1 z score) and feeding practices or annual changes in total DQIS and its individual components (as continuous variables). The models were adjusted for weight-for-length z-score at baseline and other significant confounders as assessed in the bivariate model. Statistical analyses were performed using the SPSS program (IBM SPSS Statistics for Macintosh, Version 22.0).

Results

From the 213 eligible participants for the follow-up visit, 78 participants could not be reached, 13 refused to participate, and 45 did not show up to the appointment, even after repeated attempts. Consequently, the final sample was 77 participants. Socio-demographic characteristics of the final sample are shown in Table 1. Overall, 53.2% of the children were boys with a median age at the initial visit of 10 months and in the follow-up visit of 21 months. In the initial visit, the prevalence of overweight/obesity (z-scores ≥+2 standard deviations) was 5% while in the follow-up visit it increased to 16%. A total of 24.7% and 36.4% were categorized at risk of overweight or overweight/obese (z-scores ≥1 standard deviation) in the baseline and follow-up visit, respectively. In terms of the caregivers at the follow-up visit, most were mothers, with a median age of 29 years old and most completed any postsecondary education (67.5%). Most caregivers were overweight or obese (62.3%) and perceived their infant as normal weight (91.0%). There was a significant difference between infants and toddlers' weight-for-length z-score at follow-up and parent's perception of infant's weight ($p<0.05$).

In the follow-up visit, 20.8% of the infants and toddlers were still breastfeeding. A total of 51% were exclusively breastfed for more than one month and 70.1% were formula fed (exclusively or not). Juice was introduced before 6 months in 32.5% of the infants and toddlers while only 15.6% consumed solids before 6 months old. Only 18.2% consumed cow's milk before 12 months. Results from the log-binomial regression model between these practices and weight-for-length z-score at follow-up, adjusted for weight-for-length z-score at baseline, showed that exclusive breastfeeding for less than one month was significantly associated with a higher risk of excessive weight at follow-up (RR 1.32, 95% C.I. 1.10, 1.59)

Table 1. Socio-demographic characteristics of children and caregivers/parents by weight-for-length z-score at follow-up

Variable	Overall (N=77) N (%)	Weight-for-length z-score <1 (N=49) N (%)	Weight-for-length z-score ≥1 (N=28) N (%)	P-value*
Infant's sex				
Boy	41 (53.2)	26 (33.8)	15 (19.5)	0.966
Girl	36 (46.8)	23 (29.9)	13 (16.9)	
Infant's age				
11-23 months	47 (61.0)	30 (39.0)	17 (22.1)	0.965
24-36 months	30 (39.0)	19 (24.7)	11 (14.3)	
Parent's age				
<30 y	43 (55.8)	27 (35.1)	16 (20.8)	0.862
≥30 y	34 (44.2)	22 (28.6)	12 (15.6)	
Parent's BMI				
Underweight/Normal	29 (37.7)	20 (26.0)	9 (11.7)	0.450
Overweight/Obese	48 (62.3)	29 (37.7)	19 (24.7)	
Parent's education				
≤High school	25 (32.5)	14 (18.2)	11 (14.3)	0.334
>High school	52 (67.5)	35 (45.5)	17 (22.1)	
Perception of infant's weight				
Normal	70 (91.0)	48 (62.3)	22 (28.6)	0.004**
Overweight/Obese	7 (9.0)	1 (1.3)	6 (7.8)	

*Pearson Chi-Square, Asymptotic Significance (2-sided), **Significantly different between weight-for-length z-score <1 and ≥1, P<0.05.

compared to breastfeeding for longer than one month. Also, those formula-fed had a significantly higher odds of excessive weight gain (RR 1.29; 95% C.I. 1.08, 1.54) compared to those never fed with formula. Timing of introduction of juice, solid foods or cow's milk was not associated with weight (results not shown).

From the 77 participants that completed the follow-up visit, 9 were excluded from the analysis of the DQIS as they were 6-7 months old in the initial visit and were undergoing major dietary changes through this period. Therefore, the sample size employed for the calculation of the DQIS was 68 infants and toddlers. As shown in Table 2, the median of the total diet quality score in the initial visit was 40.0 points, which significantly decreased to 27.5 points (from a range of 0-55), in the follow-up visit ($p<0.001$). When analyzing the DQIS by each component, a significant reduction was observed between the initial and follow-up visit in the following scores: milk (breast-milk only), cereals or grains (refined grains only), proteins, vegetables, fruits, 100% juices, sugar-sweetened beverages, sweets and salty snacks ($p<0.05$). No significant differences were observed in formula/cow's milk or whole grains scores between visits.

Table 2. DQIS at baseline and follow-up (n=68)*

Variable	DQIS at Baseline Median (25th, 75th)	DQIS at Follow-up Median (25th, 75th)
Breast-milk score	0 (0, 10)	0 (0, 0)**
Formula/milk score	2.5 (0, 5)	2.5 (0, 5)
Whole grains score	2.5 (2.5, 2.5)	2.5 (2.5, 2.5)
Refined grains score	2.5 (1.25, 2.5)	1.25 (1.25, 2.5)**
Proteins score	2.5 (2.5, 5)	2.5 (0, 2.5)**
Vegetables score	5 (2.5, 5)	2.5 (2.5, 2.5)**
Fruits score	5 (2.5, 5)	2.5 (2.5, 2.5)**
100% juices score	5 (1.5, 5)	5 (0, 5)**
SSB score	5 (5, 5)	2.5 (2.5, 5)**
Sweets score	5 (2.5, 5)	2.5 (2.5, 2.5)**
Salty snacks score	5 (5, 5)	5 (2.5, 5)**
Total score	40.0 (27.5, 48.1)	27.5 (23.8, 31.3)**

*9 participants were excluded from the analysis of the DQIS as they were 6-7 months old in the initial visit and were undergoing major dietary changes through this period.
**Significantly different between baseline and follow-up visits, P<0.05.

Table 3 shows the log-binomial regression model between the annual change of each component of the DQIS and weight-for-length z-score at follow-up, adjusted for weight-for-length z-score at baseline. No significant associations were found between annual change of each component of the diet score and weight status. However, a trend was observed for the annual change in vegetable, 100% juice, and breast-milk's scores; a decrease in the scores for breast milk and 100% juices components were associated with a greater risk of weight gain while negative decrease in the score for the vegetable component was associated with a lower risk of weight gain. When other potential confounders were included in the model (e.g. parents age or education), similar results were found (data not shown).

Table 3. Association between annual change in total DQIS and each DQIS component with weight-for-length z-score at follow-up (n=68)

Variable	RR*	95% CI
Breast milk score	1.07	0.98, 1.18
Formula/milk score	0.96	0.85, 1.09
Whole grains score	1.08	0.80, 1.48
Refined grains score	1.21	0.86, 1.71
Proteins score	1.05	0.92, 1.20
Vegetables score	0.80	0.63, 1.02
Fruits score	0.92	0.72, 1.17
100% juices score	1.15	0.98, 1.34
SSB score	0.96	0.76, 1.20
Sweets score	1.03	0.83, 1.27
Salty snacks score	0.95	0.72, 1.24
Total score	1.02	0.98, 1.07

*Adjusted by weight-for-length z-score at baseline

Discussion

This longitudinal study explored the associations between feeding practices and diet quality with weight status in infants and toddlers' participants of a WIC clinic in Puerto Rico. Exclusive breastfeeding for less than one month and formula-based diets significantly increased the odds of overweight/obesity at follow-up. Although DQIS decreased significantly from the baseline visit to the follow-up visit, it was not significantly associated with weight status. However, a trend in a decrease in the scores for breast milk and 100% juices components were associated with a greater risk of weight gain while a negative decrease in the score for the vegetable component was associated with a lower risk of weight gain.

Numerous studies have found that breastfeeding during the first months of life reduces the risk of overweight or obesity later in life (20,21). For instance, a meta-analysis found that ever breastfed infants had lower odds of gaining excessive weight in childhood compared to those never breastfed (21). Consistent with the literature, our study showed that a reduction in the breastmilk score was associated with higher odds of excessive weight and that exclusive breastfeeding for less than one month also increased the odds of excessive weight. Other studies have shown that feeding infants solid foods before six months of age is associated with increased weight later in life (22,23). In a longitudinal study in the US among infants followed-up from birth to 3 years old, infants who started eating solid foods before 4 months old had higher risk for obesity at the age of 3 years (23). In our study, the fact that most infants started consuming solid foods after 6 months could explain the lack of association with risk of overweight in our sample.

Furthermore, our study showed that diet quality decreased as infants' transition into childhood. This means that the infants and toddlers in our sample were failing to meet the dietary guidelines as they got older. Similarly, other studies in children, including infants and toddlers, have found that most are not meeting the recommended servings for fruits, vegetables, and milk products (24). One possible explanation

for many of these dietary tendencies is the influence of parental eating habits over their children (25). Other important aspects that are linked to children's low adherence to the dietary guidelines are lower maternal education, higher BMI, younger age, lower income, and race/ethnicity (25,26). Our sample precisely consisted of low-income, overweight or obese, Hispanic WIC participants.

While our results showed a decrease in DQIS over time, the annual change in total DQIS was not associated with a higher risk of overweight and obesity at the follow-up visit. Some studies have found positives associations between diet quality and weight status, yet conflicting results among young children have been found in the literature (27–29). For instance, a longitudinal study found an inverse association between diet quality and changes in BMI z-scores in children 5-12 years old who were overweight at the initial visit, but not in those with normal weight (27). Moreover, a prospective cohort study from UK found that children with the lowest quality diets had higher percentage of fat mass than children with superior quality diets, but no evidence was found linking diet quality and BMI (28). Similar, an Australian study found no association between dietary patterns of infants and toddlers with BMI z-scores (29). These finding suggest that more studies are needed in order to establish a relationship between diet quality and weight gain in young children. However, we did find a trend between a negative change in the score for the vegetable component and a lower risk of overweight/obesity and between a negative change in the score for 100% fruit juices and a higher risk of overweight/obesity. One possible explanation for this result is that the source of vegetable in many children 0-12 months were baby foods, and as they got older the introduction of vegetables in other forms was minimal.

Some limitations must be recognized in our study. First, around two thirds of the participants were lost in the follow-up visit, as most of them could not be reached. Additionally, the data was self-reported by the participants, and some bias could be present in the information collected. Also, the participants were selected from a specific WIC clinic, making the results not generalizable. Among the strengths, this was a longitudinal study, thus causality can be inferred. We included a population of Hispanic from a disadvantaged background and whereas little information is known. Lastly, we used a validated FFQ and diet quality score index specifically designed for infants and toddlers.

In conclusion, in this cohort of infants and toddlers' participants of the WIC program in Puerto Rico, exclusive breastfeeding for less than one month and formula-based diets significantly increased the odds of overweight/obesity at follow-up. We also observed a significant decrease in diet quality over time, and some trends for the breast-milk, vegetables and 100% juices scores with risk of overweight, although they were not significant. Longer and larger longitudinal studies are needed to understand the dietary patterns associated with excessive weight gain in young children for establishing effective interventions to prevent childhood obesity.

Resumen

Objetivo: Explorar asociaciones entre prácticas alimentarias y calidad de la dieta con el peso en infantes/andarines puertorriqueños. Métodos: Este fue un estudio longitudinal en 296 cuidadores y sus hijos de 0-24 meses de una clínica WIC en PR. Se completaron cuestionarios sobre características sociodemográficas y prácticas alimentarias y en los niños se midió peso y longitud al inicio y 1 año después (seguimiento). La calidad de la dieta se evaluó con una versión adaptada del índice de calidad de la dieta (DQIS) para infantes/andarines. Resultados: 77 participantes completaron la visita de seguimiento. En la visita inicial, el sobrepeso/obesidad fue de 5% y en la visita de seguimiento aumentó a 16%. La lactancia exclusiva por menos de un mes (RR 1.32, IC 95% 1.10, 1.59) y la alimentación con fórmula (RR 1.29, IC 95% 1.08, 1.54) aumentaron las probabilidades de sobrepeso/obesidad en la visita de seguimiento en comparación con lactancia más prolongada y alimentación sin fórmula. El DQIS disminuyó significativamente entre la visita de inicio y la de seguimiento, pero no se asoció significativamente con el peso; sin embargo, se observó una tendencia entre un cambio negativo en el puntaje de leche materna y jugos 100% con mayores probabilidades de sobrepeso/obesidad y un cambio negativo en el puntaje de vegetales con una menor probabilidad de sobrepeso/obesidad. Conclusión: La calidad de la dieta disminuyó significativamente con el tiempo. La lactancia exclusiva por menos de un mes y la alimentación con fórmula aumentaron significativamente las probabilidades de sobrepeso/obesidad en la visita de seguimiento.

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