Development of a Diet Quality Score for Infants and Toddlers and its Association with Weight

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Abstract

Objective: To create a Diet Quality Index Score (DQIS) for infants and toddlers and to assess its relative validity.

Design: Three DQIS were created (0-5, 8-11 and 12-24 months) based on a validated food frequency questionnaire (FFQ). Nine components were included, scored from 0 (inadequate) to 5 (adequate consumption) based on guidelines for timing of food's introduction and portion sizes; the component on breastfeeding (Yes/No) was scored (0-15). Infants 6-7 months were excluded as new foods are introduced during this period. The total score (0-55 points) was categorized as Excellent (≥ 45), Good (35-44), Needs improvement (25-34), and Poor (< 25). Relative validity was assessed against weight status among a sample of 296 children using logistic regression.

Results: In infants 0-5 months ($n=100$), mean DQIS was 42.4 ± 9.3 and 52% had 'Excellent' diets. In infants 8-11 months ($n=42$), mean DQIS was 36.1 ± 7.7 and most had 'Good' diets (47.6%). Among toddlers 12-24 months ($n=117$), mean DQIS was 25.7 ± 8.0 and most had 'Poor' diets (50.4%). There was a trend for a higher odd of Excessive weight in those with 'Poor' diets compared to those with 'Excellent' diets, after controlling for confounders (OR 2.01; 95% CI: 0.85, 5.18).

Conclusions: These scores could be used to assess diet quality in infants and toddlers. There was a trend for a higher odd of Excessive weight among those with 'Poor' diets. To our knowledge, this is the first algorithm for the assessment of diet quality in infants and toddlers considering intake of each food group and their portion sizes.

Keywords: Diet Quality; Diet Score; Weight Status; Infants; Toddlers

introduction of solids and altered feeding practices during these early years [1, 4, 5], but more evidence is needed.

Assessing diet quality in the population is important as this allows monitoring compliance to dietary guidelines. However, this has not been properly studied in infants and toddlers. Although several studies have characterized dietary patterns in this group [6-9], there are only three diet quality scores developed specifically for infants and toddlers [10-12]. One score was developed to assess diet quality in infants 6 months and older in the United Kingdom (UK) based on adherence to complementary feeding guidelines [10]. The index was based on 14 components related to breast feeding, timing of introduction to solids, meal frequency and other feeding practices, but it did not take into consideration the amount of food consumed. Another score entitled *Infant and Child Feeding Index* was created for infants 6-23 months based on the World Health Organization (WHO) feeding guidelines [11]. This score consists of 5 components (breastfeeding, use of the bottle, food frequency, dietary diversity and frequency of feeding solids) but it also did not take into account portion sizes. The third score was created using data from the Raine Study, a longitudinal survey in Australian children [12]. This score included the frequency of consumption of 7 components (whole grains, vegetables, fruits, meat ratio, dairy, snack foods, soda, and drinks) and was based on a modified Healthy Eating Index for children. Although it takes into account portion sizes, it did not include breastfeeding and, to our knowledge, it has not been validated.

Developing a diet score for this age group is challenging for two main reasons: (1) there are many changes occurring in a short period of time as new foods and beverages are introduced and (2) the US Dietary Guidelines does not include children 0-24 months, which difficult the creation of the score, as this usually monitors compliance to published guidelines. However, there are a few dietary guidelines currently in use for this population, such as the guidelines by the Women, Infants, and Children Nutritional Supplementation Program (WIC) [13], the WHO [14] and the

Introduction

Adequate nutrition is essential for growth and development during the first years of life and for the prevention of future chronic diseases, such as obesity, diabetes, cancer, among others [1]. Currently, childhood obesity has become one of the most alarming concerns of public health in the US [2] and it is starting earlier in life, with 8.1% prevalence of excessive weight in infants and toddlers in 2011-2012 [3]. This high prevalence in such young group could be partially attributed to the early

American Academy of Pediatrics [15]. Therefore, the aim of this study was to create a Diet Quality Index Score using the available guidelines and to assess its relative validity.

Methods

Study Design

This was a cross-sectional study to create a diet quality score in infants and toddlers 0-24 months of age. We recruited caregivers of infants and toddlers' participants of a WIC clinic in Puerto Rico. Caregivers completed a socio-demographic questionnaire and the Infant and Toddler Semi-Quantitative Food Frequency Questionnaire (FFQ). Also, weight and length were taken in the infants and toddlers. A signed consent and willingness to participate from the caregivers was obtained. This study was approved by the Institutional Review Board of the Medical Science Campus at the University of Puerto Rico.

Participants

We recruited a convenience sample of 296 caregivers of infants and toddlers aged 0-24 months. Recruitment occurred daily in the only WIC clinic in the Municipality of Trujillo Alto in Puerto Rico from November 2014 to February 2015. This allowed recruitment of all active WIC participants of that municipality. We excluded children with any serious health condition that could alter normal feeding practices.

Socio-demographic questionnaire

It included questions related to caregivers, such as age, gender, and educational attainment and questions on the infants and toddlers, such as age and gender.

Anthropometric assessment

Weight and length were assessed in children by trained research personnel. Caregivers were asked to remove diapers or put a clean diaper on the child and remove accessories such as hats, bonnets, coats, shoes, socks, bibs, etc. Weight was measured in pounds (later converted to kg) using a manual scale (Detecto model 3p7044, Missouri), which was calibrated daily. Recumbent length was measured in cm using an infantometer (Perspective Enterprises model #PE-RILB-BRG2, Michigan). Measurements were taken in duplicates and averaged. Weight status was assessed with weight-for-length using the WHO growth charts by age and sex [16]. Weight was categorized as Healthy (<90th percentile) and Excessive (≥90th percentile).

Dietary Assessments

An Infant and Toddler Semi-quantitative FFQ was used to characterize the child's food intake in the first two years of life. This FFQ includes 52 items with portion sizes and has been previously validated in a similar population [17]. A picture guide was created to aid caregivers estimate portion sizes of fruits, vegetables, milk, cereals, cookies, salted snacks, protein foods and beverages. It was completed during a face-to-face interview by trained personal.

Diet Quality Index Score (DQIS)

Three different scores were created to assess diet quality based on the Infant and Toddler semi-quantitative FFQ for the

following age groups: 0-5 months, 8-11 months and 12-24 months. We excluded participants aged 6-7 months, as this is a period of introduction of solids and other beverages, with many changes occurring every week; therefore, it is difficult to assess dietary patterns in this group.

DQIS for infants 0-5 months

For this score, we included nine components: Milk (exclusive or partial breastfeeding or formula feeding), Grains or cereals, Proteins (meat or beans), Vegetables, Fruits, 100% fruit juices, Sugar-sweetened beverages, Sweets, and Salty snacks. The scores were based only on timing of introduction of foods and beverages; for this, we considered the WIC's complementary feeding guidelines [13], the WHO feeding guidelines [14] and the recommendations of the American Academy of Pediatrics in the introduction of solids [15]. These guidelines recommend exclusive breastfeeding for infants 0-5 months, without any solid foods until 6 months (Table 1). For all the components, except for breastfeeding, 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 breastfeeding, a score of 15 points was assigned if the infant was exclusively breastfed; a score of 10 points was assigned if partially breastfed (combination of breastfeeding and formula feeding); and a score of 5 points was assigned if the infant was only formula fed. We did not take into consideration the portion sizes of the food groups for this age group.

Table 1: Diet Quality Index scoring for infants 0-5 months

Components	Scores ^a
Milk (type of feeding) ^b	15 (exclusive)
Breastfeeding	10 (partial)
Formula feeding	5
Cereal	Not consumed = 5 Consumed = 0
Protein	Not consumed = 5 Consumed = 0
Vegetables	Not consumed = 5 Consumed = 0
Fruits	Not consumed = 5 Consumed = 0
100% fruit juices	Not consumed = 5 Consumed = 0
Sugar-sweetened beverages	Not consumed = 5 Consumed = 0
Sweets	Not consumed = 5 Consumed = 0
Salty snacks	Not consumed = 5 Consumed = 0
Total	0-55

^aThe scores were based on the age of introduction of these foods as recommended by the WIC's complementary feeding guidelines [13], the WHO feeding guidelines [14] and the American Academy of Pediatrics [15], not on portion sizes.

^bThe score for Milk (Type of feeding) was based on YES/NO, without quantifying the amount of breast milk or formula.

DQIS for infants 8-11 months

For this score, we included the same nine components. The scores were based on recommended portions following WIC's recommendations [13], the WHO feeding guidelines [14] and the Child and Adult Care Food Program Proposed Meal Pattern [18] (Table 2). We considered under and over consumption of each food group and the scores were as follows: 5 points if intake was within recommended amounts; 2.5 points if intake was slightly over or under the recommended amount; or 0 points if it was not consumed or intake was excessive. For the Milk group, two different scores were included. The first score assigned 10 points if the infant was breastfed (partially or exclusively) and 0 if the infant was not breastfed (the amount of breast milk was not taken into account). The second score took into consideration

the amount of total milk consumed (formula, cow's milk, almond milk, and soy milk but not breast milk) and assigned 5 points if intake was within recommended amounts; 2.5 points if intake was slightly over or under the recommended amount; or 0 points if it was not consumed or intake was excessive.

DQIS for infants 12-24 months

For this score, we used a similar scoring system as for infants 8-11 months, but we adjusted the portion sizes using the same guidelines (Table 2).

DQIS categorization

The individual components scores were summed for each infant and toddler and a total score was obtained ranging from 0 to 55 points. The total score was categorized as:

Table 2: Diet Quality Index Score for infants and toddlers 8-24 months.

Component	Score	8-11 months (portions ^a)	12-24 months (portions ^a)
Milk			
Breast feeding ^b	10 5	Yes 20-28	Yes 14-18
Formula/Cow's milk/other milks (fl oz/d)	2.5 0	8.0-19.9 or 28.1-35.0 <8 or >35	8.0-13.9 or 18.1-24.0 <8.0 or >24.0
Grains			
Whole grains (oz/d) ^c	2.5 1.25 0	1.0-3.5 0.1-0.9 or 3.6-8.0 0 or >8.0	1.5-5.5 0.1-1.4 or 5.6-8.0 0 or >8.0
Refined grains (oz/d) ^c	2.5 1.25 0	0-1.5 1.6-3.5 >3.5	0-1.8 1.9-4.2 >4.2
Proteins^d (oz/d)	5 2.5 0	2.5-6.0 0.1-2.4 or 6.1-10.0 0 or >10	2.0-3.0 0.1-1.9 or 3.1-6.0 0 or >6.0
Vegetables (oz/d)	5 2.5 0	≥2.0 0.1-1.9 0	≥8.0 0.1-7.9 0
Fruits (oz/d)	5 2.5 0	≥2.0 0.1-1.9 0	≥8.0 0.1-7.9 0
100% fruit juices (fl oz/d)	5 2.5 0	≥2.0 0.1-6.0 >6.0	0-4.0 4.1-6.0 >6.0
Sugar-sweetened beverages (fl oz/d)	5 2.5 0	0 0.1-4 >4	0 0.1-4 >4
Sweets^e (servings/d)	5 2.5 0	≥2.0 0.1-1.0 >1.0	0-4.0 0.1-1.0 >1.0
Salty snacks^f (oz/d)	5 2.5 0	≥2.0 0.1-1.0 >1.0	0-4.0 0.1-1.0 >1.0

^aPortion sizes were determined from the WIC's recommendations [13], the WHO feeding guidelines [14] and the Child and Adult Care Food Program Proposed Meal Pattern [18]

^bThe score for breastfeeding (exclusively or partial) was based on YES/NO, without quantifying the amount of breast milk.

^cThe score for Grains and Cereals were divided between whole grains (max score 2.5) and refined grains (max score 2.5) for a total of 5.0 points for this group.

^dFor infants 8-11 months, these portions considered diluted and pureed meats and beans while for infants 12-24 months, these portions were for regular meat and beans portions;

^eIncludes candies, cookies, biscuits, cakes, muffins, etc.

^fIncludes chips, and other similar products.

- Excellent, if the total score was ≥ 45 ;
- Good, if the total score was 35-44;
- Needs improvement, if the total score was 25-34; and
- Poor, if the total score was < 25 .

Statistical analysis

For descriptive statistics, mean and standard deviations were computed for continuous variables and frequencies for categorical values. A binary logistic regression was conducted to examine the associations between weight status (Healthy versus Excessive weight) and the categorized DQIS. The model was adjusted for caregiver's age and education. All analyses were performed using SPSS Statistical Software (version 21.0 for Windows, 2012, Chicago, IL) and Excel (Microsoft, 2010). Statistical significance was set at $P < 0.05$.

Results

Table 3 shows the socio-demographic characteristics of the sample. A total of 296 participants were recruited. From these, four caregivers did not complete all the questionnaires, one child was not weighed and one child was older than 24 months. Also, infants aged 6-7 months ($n=31$) were excluded, as described in Methods. Therefore, a total of 259 caregivers and their children

Table 3: General characteristics of caregivers and their infants/toddlers ($n=259$)

Characteristics		Total sample % (N) or Mean (SD)
Caregivers		
Gender (female)		98.8 (256)
Age (years)		28.3 $\pm$ 6.7
Education	$\leq$ High School $>$ High School	40.6 (105) 59.4 (154)
Number of children in household		1.9 $\pm$ 1.0
Infants/Toddlers		
Gender	Female Male	46.0 (119) 54.0 (140)
Age	0-5 months 8-11 months 12-24 months	38.6 (100) 16.2 (42) 45.2 (117)
Weight status^a		
0-5 months	Healthy weight	83.0 (83)
	Excessive weight	17.0 (17)
8-11 months	Healthy weight	85.7 (36)
	Excessive weight	14.3 (6)
12-24 months	Healthy weight	74.4 (87)
	Excessive weight	25.6 (30)

^aWeight Status was categorized as: Healthy weight ($< 90^{\text{th}}$ percentile) and Excessive weight as $\geq 90^{\text{th}}$ percentile.

Table 4: Diet Quality Index Score by age groups

Component	Diet quality index score					
	0-5 months (n=100)		8-11 months (n=42)		12-24 months (n=117)	
	Max Score	Mean $\pm$ SD	Max Score	Mean $\pm$ SD	Max Score	Mean $\pm$ SD
Breastfeeding (Yes/ No)	15	5.9 $\pm$ 5.8	10	4.3 $\pm$ 5.0	10	2.4 $\pm$ 4.3
Any milk (breast, formula, cow, others) (fl oz/d)		-	5	2.8 $\pm$ 1.8	5	4.3 $\pm$ 1.7
Grains or cereals (oz/d)	5	5.0 $\pm$ 0.0		-		-
Whole grains (oz/d)		-	2.5	1.2 $\pm$ 0.9	2.5	1.2 $\pm$ 0.8
Refined grains (oz/d)		-	2.5	1.1 $\pm$ 1.1	2.5	0.4 $\pm$ 0.7
Proteins (oz/d)	5	5.0 $\pm$ 0.0	5	2.5 $\pm$ 1.8	5	1.3 $\pm$ 1.7
Vegetables (oz/d)	5	5.0 $\pm$ 0.0	5	3.8 $\pm$ 1.6	5	3.9 $\pm$ 1.3
Fruits (oz/d)	5	5.0 $\pm$ 0.0	5	4.5 $\pm$ 1.2	5	4.0 $\pm$ 1.5
100% Juices (fl oz/d)	5	5.0 $\pm$ 0.0	5	2.5 $\pm$ 1.7	5	1.9 $\pm$ 2.3
Sugar-sweetened beverages (fl oz/d)	5	5.0 $\pm$ 0.0	5	4.8 $\pm$ 0.9	5	2.3 $\pm$ 1.7
Sweets (servings/d)	5	5.0 $\pm$ 0.0	5	3.9 $\pm$ 1.5	5	1.8 $\pm$ 1.6
Salty snacks (oz/d)	5	5.0 $\pm$ 0.0	5	4.8 $\pm$ 0.7	5	3.9 $\pm$ 1.3
TOTAL	55	42.4 $\pm$ 9.3	55	36.1 $\pm$ 7.7	55	25.7 $\pm$ 8.0

Table 5: Association between Diet Quality Index Score and overweight¹

Diet Quality Index Score	OR	95% CI	Adjusted OR ²	95% CI
Poor	2.01	(0.82, 4.95)	2.01	(0.85, 5.18)
Needs improvement	0.84	(0.30, 2.34)	0.83	(0.30, 2.34)
Good	1.63	(0.67, 3.97)	1.61	(0.66, 3.95)
Excellent	1		1	

¹Healthy weight was used as the reference.

²Adjusted for caregiver's age and education

(0-5 months $n=100$; 8-11 months $n=42$; 12-24 months $n=117$) were included in the analysis. Most caregivers were females (98.8%) and had a level of education higher than high school (59.4%). A total of 54% of infants were male and 45% were aged 12-24 months. In general, excessive weight was found in 20.5% of the sample, with a higher prevalence among toddlers aged 12-24 months (25.6%).

The mean DQIS in infants 0-5 months was 42.4 ± 9.3 out of a total of 55 points (Table 4). Most were categorized as having 'Excellent' diets (52.0%), followed by 'Good' diet (36.0%), diets that 'Need improvement' (8.0%) and 'Poor' diet (4.0%). The mean DQIS in infants 8-11 months was 36.1 ± 7.7 out of a total of 55 points (Table 4). Most were categorized as having 'Good' diets (47.6%), followed by diets that 'Need improvement' (35.7%), 'Excellent' diets (14.3%) and 'Poor' diets (2.4%). The lowest scores were for Breastfeeding, 100% fruit juices, and Proteins. The low scores for 100% fruit juices and Proteins were due to their overconsumption.

In particular, 26% of participants reported consuming ≥ 6 fluid ounces of 100% fruit juices (recommended amount for this age group is 0 ounces) and 24% participants reported consuming ≥ 6 ounces of foods from the protein group (recommended amount for this age group is 2.5 to 6.0 ounces). The mean DQIS in infants 12-24 months was 25.7 ± 8.0 out of a total of 55 points (Table 4). Most were categorized as having 'Poor' diets (50.4%), followed by diets that 'Need improvement' (32.5%), 'Good' diets (16.2%) and 'Excellent' diets (0.9%). The lowest scores were for the following components: Milk, Proteins, Refined grains and 100% fruit juices; this was also due to overconsumption of these groups. In particular, we noted that 72% of infants consumed more than 18 ounces of milk (recommended amount for this age group is 14 to 18 ounces), with an average consumption of 26 ounces per day. Also, 81% of infants consumed more than 3 ounces of proteins (recommended amount for this age group is 2 to 3 ounces), with an average consumption of 8.7 ounces per day, which is more than double of the recommended amount. In addition, 68% consumed more than 4 ounces of 100% fruit juices (recommended amount for this age group is up to 4 ounces per day), with an average consumption of 8.4 ounces per day, which is double of the recommended amount.

In terms of relative validity, we found a trend between DQIS categories and weight status, in which those categorized as having 'Poor' diets had two-fold higher odds of Excessive weight compared to those categorized as having 'Excellent' diets, after controlling for caregiver's age and education (OR 2.01; 95% CI: 0.85, 5.18).

Discussion

In the present study we designed a DQIS following the available guidelines for timing of introduction of solids for infants 0-5 months and the guidelines for the recommended portion sizes of different food groups for infants 8-24 months [13-15, 18]. There was a trend in the association of the DQIS with weight status, with a two-fold increase in Excessive weight among infants and toddlers with 'Poor' diets compared to those with 'Excellent' diets.

To our knowledge, this is the first attempt to create and validate a diet quality score for infants and toddlers considering the intake of each food group and their portion sizes (for infants 8-24 months). As mentioned earlier, a few other scores have been created to assess diet quality in both infants and toddlers. Two of the available scores do not take into account portion sizes [10, 11] the third score includes portion sizes but did not take into account breastfeeding and has not been validated [12]. Therefore, this study is filling a gap for a score that is based on the amount of food consumed while also taking into account type of feeding practices. In addition, as feeding practices change considerably during this period, we created three different scores.

In infants 0-5 months, the score basically assessed breastfeeding and timing of introduction of solids. Our results showed that the score was very high, with most infants categorized as having 'Excellent' or 'Good' diets (88%). This indicates that most caregivers are compliant with the guidelines

on age of introduction of complementary feeding and with the recommendation to breastfeed their infants.

Most infants 8-11 months also had 'Good' or 'Excellent' diets (61.9%), indicating that most were compliant with the different feeding guidelines. Similar results were seen in the score created in the UK for infants 6 months and older, where the score reflected adherence to complementary guidelines [10]. In our sample, one of the components with the lowest scores was 100% fruit juices. This item is actually not recommended for this age group, so we assigned a score of 5 if consumption was 0 and a score of 0 if consumption was above 6 ounces per day. The consumption of 100% fruit juices has been traditionally perceived by parents as healthy, as these contain vitamins and minerals [19, 20]. In fact, the food industry has developed juices specifically for babies, with jars that can be adjusted using the infant bottle's nipple. However, these beverages also contain high amounts of sugar, contributing to excessive sugar intake in the US [21]. In the case of proteins, the low scores in our study were due to overconsumption. The fact that our score was able to take into account overconsumption enabled us to detect and quantify this issue. Recommendations to address overconsumption of foods are needed.

In toddlers (12-24 months), most were categorized as 'Poor' diets (50.4%). This was not explained by an increase in the intake of sugar-sweetened beverages and unhealthy foods as seen by others [12] but again by the over consumption of foods considered healthy: milk, 100% fruit juices and protein rich foods. In particular, average consumption of milk was 26 ounces per day, which represents more than 3 bottles of 8 ounces. Although we did not systematically record it, participants reported using the milk bottle to feed the baby, adding cereals and baby foods to the milk bottle. Future studies should quantify this practice. Overconsumption of milk among infants has also been reported by others [22]. Excess milk intake could be associated with anemia and nutrient deficiencies, among other health problems [23]. In addition, a recent systematic review of 10 studies in infants concluded that high intakes of energy and protein, particularly dairy products, could be associated with higher BMI and body fatness [5].

With respect to the relative validity of the DQIS, we found a trend in the association between the score and weight status, whereas those having 'Poor' diets had a two-fold increase in the odds of Excessive weight compared to those having 'Excellent' diets. On the contrary, the score developed in the UK did not find an association between the score and BMI later in childhood [10]. Longitudinal studies are needed to evaluate if the DQIS is related to obesity later in childhood.

The findings of the present study can provide relevant information to the B-24 project. This project evaluates the evidence to support including infants and toddlers from birth to 24 months of age in the Dietary Guidelines for Americans (DGA) [24]. The main focus of the B-24 project is to revise the latest systematic reviews on important topics involving infant's nutrition and health for creating the DGA in this age group. In

the past, this population was excluded from the DGA due to the limited information available. Today, studies have shown the importance of nutrition in this targeted population for the prevention of chronic diseases later in life [1, 4]. The score created in the present study could be used to assess diet quality in different studies and relate this score to the development of obesity and other chronic conditions later in life, which could inform the B-24 project.

There are some limitations and strengths about the present study that should be taken into account when considering the results. One limitation of the study was related to the difficulty for some caregivers to recall the foods and beverages consumed by their infants and to estimate the portion sizes of the different foods consumed. This was in part overcome by having a picture guide of portion sizes for the most common foods consumed by infants and toddlers. A strength of the study was that the DQIS created was based on a validated semi-quantitative FFQ specifically designed for infants and toddlers 0-24 months. This allowed taking into account amount of foods consumed, not only if the food was consumed or introduced. Anthropometric measurements and all questionnaires were completed by trained personnel using standardized methods and equipment, increasing accuracy in the data obtained.

In conclusion, to our knowledge, this is the first attempt to assess diet quality in infants and toddlers considering intake of each food group and their portion sizes (for infants 8-24 months). Three DQIS were created to assess diet quality in infants and toddlers aged 0-24 months. There was a trend for a two-fold increase in Excessive weight among those with 'Poor' diets. Longitudinal studies are needed to evaluate if a low DQIS is related to obesity later in childhood in this sample and in other populations.

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Declarations

- Conflict of Interest: There is no conflict of interest to disclose.
- Ethical Approval: This study was approved by the Institutional Review Board of the Medical Science Campus at the University of Puerto Rico.

- Clinical trial registration: This was an observational study. A signed consent and willingness to participate from the caregivers was obtained before the study start.

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