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ORIGINAL ARTICLE

Eating Habits and Dietary Status in Young Children with Autism

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Abstract While clinical lore appears to accept that young children with autism have limited or narrow diets and unusual food aversions in comparison to same age peers, the empirical basis for this is missing. The goals of this preliminary study were to examine the eating habits and nutritional intake of a young cohort of well characterized children with autism compared to young children with no evidence of autism or other autism spectrum disorders. Parents reported on 19 young children with autism and 15 similar aged children with typical development using a number of informant instruments. Results indicated that children with autism had more mealtime behavioral differences, but these did not translate to significant differences in nutritional status compared to typically developing children. However, there was much variability within both groups. Results are discussed in relationship to what has been previously found in older children with autism spectrum disorders.

Keywords Autism · Diet · Eating habits · Nutrition · Young children

Autism is a severe, yet increasingly common neurodevelopmental disorder with diagnostic features that include qualitative impairment in social interactions (e.g., lack of social reciprocity, marked impairment in eye-to-eye gaze, lack of joint attention), qualitative impairments in communication (e.g., lack of language development, echolalia, stereotyped, and repetitive use of language), and restricted repetitive and

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stereotyped patterns of behavior, interests, and activities (APA 2000). A recent large survey of young children estimated a prevalence rate of 22 children per 10,000 in the general population for autism and 60 per 10,000 for the broader phenotypes of autism spectrum disorders (ASD; Chakrabarti and Fombonne 2005). A large percentage of individuals with developmental differences, including ASD, has been found to present with comorbid feeding problems (Field et al. 2003; Palmer and Horn 1978). While atypical dietary patterns are not considered a diagnostic symptom for ASD at present, aberrant eating habits were, in fact, included among earlier defined features of the disorder (Ritvo and Freeman 1978). Over 90% of children with autism were reported to have some problems around mealtimes in an early report (DeMeyer 1979). In the ensuing years, there have been several reports in the literature documenting feeding and mealtime problems among individuals with ASD. These problems have tended to fall into one of three categories: (1) food selectivity based on type and texture, (2) food refusal, and (3) disruptive mealtime behaviors (Ahearn et al. 2001). In a descriptive study of a sample of 20 children from 3 to 14 years of age with ASD, Ahearn et al. (2001) reported that 50% of the sample demonstrated food selectivity by type or texture based on direct feeding assessment. Schreck and colleagues assessed rates of narrow food preferences and food selectivity in children with ASD, based on questionnaires completed by parents (Schreck and Williams 2006; Schreck et al. 2004b; Williams et al. 2005). Only one of these studies included a comparison group of typically developing children or children with other developmental disorders. Collectively, these reports have added to the characterization of feeding and mealtime issues in children with autism and indicate that children with autism have more behavioral issues around mealtime and are more narrow in the foods they accept.

The extent to which feeding problems relate to detrimental nutritional status has received less attention in the literature. Raiten and Massaro (1986) examined dietary intake of mealtimes for seven consecutive days in a sample of 40 children with autism compared to 36 typical children. Surprisingly, children with autism were shown to have higher intake of protein and carbohydrates as well as niacin, thiamin, riboflavin, calcium, phosphorus, and iron. More recently, Lindsay et al. (2006) examined the nutritional status of 20 children with autism who were participants in a randomized placebo-controlled trial of risperidone for significant disruptive behaviors. Data reflected that this sample of children met dietary intake standards. However, there was much variability in the group. For example, calcium intake was less than recommended in 50% of the sample. Yet, four participants consumed much higher levels of calcium than was recommended. The current study extends this prior work by examining the dietary habits and nutritional status in a sample of well characterized young children with autism and a sample of age matched, typically developing peers. While clinical lore appears to accept that young children with autism have limited or narrow diets and unusual food aversions in comparison to same age peers, the empirical basis for this is missing. In fact, at the recently convened, invitational meeting (National Institute of Health Workshop on Diet, Nutrition, & Dietary Supplements in Autism: Evaluation of the Evidence, 2005), a resounding theme was the need for scientific characterization of individuals with autism's dietary habits and nutritional status. Better characterization of the diets and nutritional intake in young children with autism is essential in understanding the extent of deviations. It is also during these younger years where many families seek

both dietary changes and dietary supplements in the treatment of autism, but without solid knowledge of the current dietary habits and nutritional status.

The goals of this preliminary study were to examine the eating habits and nutritional intake of a young cohort of well characterized children with autism compared to young children with no evidence of ASD. This preliminary study tested the hypotheses that: (1) young children with autism have more mealtime behavior problems and a more restricted range of accepted foods and types of food textures accepted compared to young children without autism; (2) young children with autism will have greater nutritional deficits compared to young children without autism; and (3) young children with autism with behavioral issues around mealtime will have more clinically significant behavioral issues in general.

Method

Participants

This study was approved by the University of Pittsburgh Institutional Review Board. Prior to participation, written informed consent was obtained from parents of all participants. Participants included 19 children with autism and 15 typically developing children (TD) between the ages of two to four years. Participants with autism were recruited through Children's Hospital of Pittsburgh's Child Development Unit/Autism Center while typically developing children were recruited through Children's Hospital Primary Care Center and from local advertising. None of the children recruited was on any dietary restrictions, such as a gluten and or casein free diet. For children with autism, diagnosis of autism was corroborated by administration of the Autism Diagnostic Observation System (Lord et al. 2002) in addition to clinical DSM-IV criteria. The typically developing control participants were screened to be free of neurological disorders and to have achieved typical developmental milestones currently and in the past, based on information documented on a developmental and medical history form. Prior to participation, written informed consent was obtained from the parents of all children.

Measures

Developmental and Medical History Form

A modified version of the Child Development Unit Developmental and Medical History form was be used to obtain demographic information as well as to determine typical development in the TD group, as well as to document any medical issues in both groups. Medical issues included parental report of any medical concerns during pregnancy, delivery and the postnatal period, as well as during early childhood.

Autism Diagnostic Observation System (ADOS; Lord et al. 2002)

The ADOS is a standardized, interactive protocol for direct observation of social and communicative behaviors associated with autism, and consists of structured and semi-

structured methods for interaction. Although the protocol follows standard administration, the situations themselves are unstructured. Thus, the ADOS provides a sample of the child's behavior in a naturalistic setting. Behaviors are coded in the areas of social communication, social relatedness, play and imagination, and repetitive behaviors. The ADOS provides a DSM-IV based algorithm for the diagnosis of autism, non-autistic, PDD, and non-PDD. This diagnostic instrument was only administered to the autism group to confirm diagnosis.

Mullen Tests of Early Learning: AGS Edition (Mullen 1995)

This is a measure of cognitive functioning for children from birth through 68 months. The Mullen provides standardized scores across five domains: Visual Reception (nonverbal problem-solving skills), Receptive Language, Expressive Language, Fine Motor skills, and Gross Motor skills. The Mullen was standardized on 1,849 young children and has solid reliability. This measure was administered to the children with autism only.

Feeding Assessment Survey (FAS)

This investigator-developed survey (CJ) was used to gather information about children's behavior problems around feeding and was revised for this study. The FAS is a 10-item questionnaire that asks parents to rate of range of mealtime behaviors using a 4 point Likert scale (total score range of 0 to 30; see Appendix).

Food Frequency Questionnaire (FFQ) (Yarnell et al. 1983)

This is a well developed and widely used questionnaire used to validly differentiate high and low caloric intake consumption (Fehily 1993). It is a measure commonly utilized in eating behavior research (Anderson et al. 1994). The FFQ, while originally designed to be self-administered, has been used as an informant report (parent report on their children's food frequency intake) in a large, randomized controlled trial of risperidone in children with autism (reference?). Hence, there is a precedent for its use in the manner described in the present study.

24 h Dietary Recall Interview (Johnson et al. 1986)

In addition to the FFQ, a 24-h Dietary Recall Interview was conducted. Parents were interviewed to determine what their child consumed during the previous day on the day informed consent was obtained. A parent was instructed to provide only what they had knowledge about regarding their child's food consumption. This strategy has been shown to be highly correlated with three day diet records and other reliable dietary assessment approaches (Mullenbach et al. 1992; Posner et al. 1992). The information from the 24 h diet recall was analyzed using a specialized software program and yielded data that was used to determine the adequacy or inadequacy of intake (Food Processor, Version 8.5 2005). While this method of assessing a child's nutritional intake has limitations with respect to validity and reliability (e.g., the child may not have been with the parent, the parent may not be able to remember),

these procedures have been widely used in the study of children's daily nutritional intake. In the event a parent has not been with the child the previous day at mealtimes, this was treated as missing data for that subject.

Child Behavior Checklist 1 1/2-5 (CBCL/1 1/2-5; Achenbach 2000)

The CBCL is a broad band, well validated behavior rating tool that is widely used both clinically and for research purposes. This parent completed scale contains 99 items and comprises seven subscales, including (1) emotional regulation, (2) anxious/depressed, (3) somatic complaints, (4) withdrawn, (5) attention problems, (6) aggressive behaviors, and (7) sleep problems. In addition to these subscales, a total problem score and two broad band-scores (internalizing and externalizing) may be calculated. This measure was administered to characterize behavioral presentation of both groups.

Procedures

A detailed Developmental and Medical History form was completed by the parents in order to assure the subjects met study inclusion criteria. This also allowed us to look at any differences in the two groups with respect to reported medical problems. For children with autism, the ADOS was administered to confirm diagnosis. The Mullen's was also administered.

Analytic Methods

Measures were scored and results were entered into Excel worksheets. The FFQ data was first analyzed by the FFQ Processing System. The FFQs were scanned and converted into ASCII data. These data were then exported to anExcel file. The 24-h Dietary Recall Interview data were analyzed using Food Processor (Version 8.5) (2005). Data were likewise exported to an Excel worksheet. Statistical analyses were conducted using the Statistical Package for Social Sciences (Version 15).

Results

Table 1 provides characterization of the study participants in the two groups. The two groups did not differ significantly on age (t=0.869; p=0.392). However, the two groups differed in the frequency of three medical concerns listed on the *Developmental and Medical History Form.* These included eating problems (χ^2=7.823, p=0.011), staring spells (χ^2=4.911; p=0.049), unusual movements (χ^2=4.911, p=0.049). There were no significant differences on rate of parent reports of headaches, stomachaches, pains, poor growth, ear infections, seizures, breathing problems, sleep problems, food allergies, drug allergies, or other allergies.

Differences in mealtime behaviors between the children with autism and controls were analyzed by calculating independent t tests for each of the items on the questionnaire and for the total number of mealtime behaviors. These data are presented in Table 2. On four of the 10 items, young children with autism presented with significantly more behavior differences. They threw food more often and had

Table 1 Characteristics of sample

	Autism (n=19)		Controls (n=15)	
	M	SD	M	SD
Age (in months)	39.20	8.98	36.4	9.46
ADOS Algorithm score	37.16	7.71	–	
Mullen Early Learning Composite Score	59.80	11.66	–	
Externalizing T-score CBCL	55.79	9.57	44.73	4.11
Internalizing T-score CBCL	59.37	8.526	39.67	7.12

higher rates of food refusal based on texture, color, and food group compared to the control participants.

A one way analysis of variance (ANOVA) was conducted to examine group difference on the FFQ. Table 3 provides results of the variables analyzed from the FFQ. Few significant differences in the nutritional intake between the two groups were evidenced. Significant differences were found in intake of vegetables ($F_{(1, 31)}$= 13.31; p=0.001) and Vitamin K ($F_{(1, 31)}$=5.686, p=0.023). Given the large standard deviations, we wished to look at frequency of children in each group whose intake was considered adequate intake (100% of recommended allowances) or inadequate (<80%), based on Dietary Reference Intakes (DRIs) and Recommended Dietary Allowances (RDAs) from the US National Academy of Sciences Food and Nutrition Board (Food and Nutrition Board 2000). These frequencies and corresponding percentages are provided in Table 4. The groups differed significantly only in the percentage of children with autism who did not receive adequate amounts of Vitamin K compared to the controls.

Differences in the two groups on the 24 h Dietary Recall Interview were examined using ANOVA as well. These results are provided in Table 5. The only significant difference was in Vitamin K ($F_{(1, 31)}$=5.493; p=026). The frequencies of those children in both groups with adequate versus inadequate intake based on this measure are provided in Table 6. The only statistically significant difference between the two groups was on the adequacy of magnesium intake. A higher percentage of control subjects did not receive adequate magnesium.

Table 2 Mean scores and significant level from feeding assessment questionnaire

	Autism (n=18)		Control (n=15)		T	Sign. (2-tailed)
	M	SD	M	SD		
Throws food	0.72	0.895	0.20	0.414	2.209	0.037
Spits food	0.28	0.575	0.27	0.458	0.061	0.952
Cries, Screams	1.00	0.840	0.73	0.594	1.032	0.310
Leaves table	1.67	1.237	1.07	0.799	1.680	0.104
Takes others food	0.67	0.767	0.47	0.516	0.860	0.397
Refuses foods of certain texture	1.89	1.183	0.53	0.743	4.005	0.000
Refuses foods of certain color	1.17	1.150	0.27	0.594	2.889	0.008
Refuses food of certain food groups	2.22	1.166	0.67	0.900	4.221	0.000
Eats only a small amount	1.28	0.895	0.87	0.834	1.355	0.185
Eats too much	0.50	0.786	0.04	0.507	0.424	0.674
TOTAL	11.39	4.972	5.47	3.378	3.916	0.000

Table 3 FFQ variables

	Autism (n=19)		Control (n=14)		F (1, 31)	Sign. Level
	M	SD	M	SD		
Primary energy source						
Total calories (kcal)	1783.51	602.08	1706.77	576.04	0.136	0.715
Carbohydrate intake (gm)	252.19	94.17	228.48	78.79	0.584	0.450
Protein intake (gm)	62.60	19.86	73.32	25.87	1.82	0.188
Fat						
Fat intake (gm)	62.69	23.08	59.64	23.68	0.138	0.713
Carbohydrates						
Total sugar (gm)	133.42	82.31	125.567	67.29	0.085	0.772
Fiber						
Fiber (gm)	14.39	5.04	14.86	5.48	0.66	0.798
Minerals						
Calcium (mg)	1015.56	676.14	1370.72	425.97	2.98	0.094
Phosphorous (mg)	1251.12	537.65	1528.55	463.61	2.41	0.131
Magnesium (mg)	275.73	108.59	295.63	133.25	0.223	0.640
Iron (mg)	13.16	4.97	11.65	5.37	0.689	0.413
Zinc (mg)	9.20	2.84	10.17	3.87	0.691	0.412
Selenium (mcg)	86.67	26.51	98.75	38.40	1.143	0.293
Sodium (mg)	2409.92	802.35	2645.53	731.73	0.748	0.394
Vitamins						
Vitamin D (mcg)	6.80	5.95	8.91	3.56	1.38	0.249
Vitamin K (mcg)	40.98	20.65	58.68	28.77	4.24	0.048
Vitamin C (mg)	83.69	81.97	60.59	31.77	0.995	0.326
Thiamin (mg)	1.49	0.42	1.46	0.47	0.043	0.838
Riboflavin (mg)	2.19	1.01	2.48	0.71	0.818	0.373
Niacin (mg)	17.69	5.74	15.39	5.03	1.44	0.239
Pantothenic acid (mg)	4.87	2.23	5.82	2.61	1.26	0.270
Vitamin B6 (mg)	1.78	0.58	1.64	0.57	0.535	0.470
Folate (mcg)	353.66	121.30	317.12	74.60	0.989	0.328
Vitamin B12 (mcg)	5.28	2.62	6.32	2.35	1.37	0.252
Fatty acids						
Omega 3 (mg)	0.88	0.32	1.04	0.48	1.223	0.277
PFA (mg)	11.81	5.64	11.27	5.738	0.072	0.790
Amino acids						
Tryptophan (mg)	0.75	0.26	0.891	0.31	1.958	0.172
Other						
Water (gm)	1653.15	763.60	1700.92	730.56	0.033	0.858
Fruit (gm)	3.40	2.76	2.74	2.04	0.583	0.451
Vegetable (gm)	0.47	0.49	1.17	0.61	13.48	0.001

Spearman rho correlation coefficients were calculated to determine correlations between the Child Behavior Checklist and the mean total score from the Feeding Behavior Assessment among the autism group. Only the Somatic Complaints factor (r=0.544; p=0.022) was significantly correlated.

Discussion

In this small sample of well characterized young children with autism, parents of children with autism rated more feeding problems, particularly related to idiosyncratic refusal of foods based on color, texture, and type than did parents of typically developing

Table 4 Summary of individual nutritional balance based on FFQ

	Autism (n=19)				Control (n=14)			
	≥100%		< 80%		≥100%		< 80%	
	Freq	%	Freq	%	Freq	%	Freq	%
Kilocalories (kcal)	15	79	2	10	11	79	1	7
Carbohydrates (gm)	19	100	0	0	13	93	0	0
Protein (gm)	19	100	0	0	14	100	0	0
Fat (gm)	18	95	0	0	12	86	2	14
Fiber (g)	4	21	10	53	2	14	8	57
Folate (mcg)	**19**	**100**	**0**	**0**	**14**	**100**	**0**	**0**
Iron (mg)	**14**	**74**	**5**	**26**	**11**	**79**	**0**	**0**
Magnesium (mg)	**19**	**100**	**0**	**0**	**14**	**100**	**0**	**0**
Potassium (mg)	**3**	**16**	**10**	**53**	**3**	**21**	**4**	**29**
Niacin (mg)	**19**	**100**	**0**	**0**	**14**	**100**	**0**	**0**
Pantothenic acid (mg)	19	100	0	0	14	100	0	0
Riboflavin (mg)	**19**	**100**	**0**	**0**	**14**	**100**	**0**	**0**
Zinc (mg)	**19**	**100**	**0**	**0**	**14**	**100**	**0**	**0**
Calcium	16	84	2	10	14	100	0	0
Sodium	19	100	0	0	14	100	0	0
Vitamin B6 (mg)	**19**	**100**	**0**	**0**	**14**	**100**	**0**	**0**
Vitamin B12 (mg)	19	100	0	0	14	100	0	0
Vitamin C (mg)	**19**	**100**	**0**	**0**	**14**	**100**	**0**	**0**
Vitamin K (mg)*	12	63	5	26	14	100	0	0

Recommended Dietary Allowances (RDAs) in bold type and Adequate Intake (AIs) in ordinary type
*p=0.48

Table 5 24 h diet recall variables

	Autism (n=18)		Control (n=15)		F (1, 31)	Sign. Level
	M	SD	M	SD		
Primary energy source						
Total calories (kcal)	1160.98	447.06	1207.24	269.68	0.123	0.728
Carbohydrate intake (gm)	226.83	235.09	168.69	54.35	0.874	0.357
Protein intake (gm)	38.52	16.39	46.88	16.50	2.26	0.143
Cholesterol						
Cholesterol	78.80	45.54	114.81	125.23	1.29	0.265
Fat						
Fat intake (gm)	38.10	13.90	40.97	7.66	0.512	0.480
Fiber						
Fiber (gm)	10.50	6.53	11.75	6.36	0.306	0.584
Minerals						
Magnesium (mg)	110.50	47.57	82.83	81.70	1.472	0.234
Iron (mg)	10.26	10.47	10.17	8.40	0.004	0.948
Potassium	1384.47	739.79	1228.29	586.32	0.438	0.513
Zinc (mg)	4.78	2.42	4.70	3.30	0.006	0.937
Sodium (mg)	1550.86	854.92	1733.11	841.85	0.377	0.544
Vitamins						
Vitamin K (mcg)	3.71	3.48	10.56	11.85	5.493	0.026
Vitamin C (mg)	60.11	83.91	59.97	62.79	0.000	0.996
Riboflavin (mg)	1.10	0.69	1.10	0.61	0.001	0.980
Niacin (mg)	10.33	4.72	12.33	6.02	1.155	0.291
Pantothenic acid (mg)	1.72	1.14	1.96	1.53	0.269	0.608

Table 6 Summary of individual nutritional balance based on 24 hour diet recall history

	Autism (n=18)				Control (n=15)			
	≥100%		< 80%		≥100%		< 80%	
	Freq	%	Freq	%	Freq	%	Freq	%
Kilocalories (kcal)	6	33	9	50	8	53	6	40
Carbohydrates (gm)	14	78	2	11	13	87	2	13
Protein (gm)	18	100	0	0	15	100	0	0
Fat (gm)	12	67	3	17	14	93	0	0
Fiber (g)	1	6	16	89	2	13	12	80
Folate (mcg)	**9**	**50**	**9**	**50**	**7**	**47**	**7**	**47**
Iron (mg)	**9**	**50**	**7**	**39**	**10**	**67**	**3**	**20**
Magnesium (mg)*	**12**	**67**	**1**	**6**	**6**	**40**	**8**	**53**
Niacin (mg)	**15**	**83**	**1**	**6**	**14**	**93**	**1**	**7**
Pantothenic acid (mg)	6	33	9	50	6	40	9	60
Riboflavin (mg)	**12**	**67**	**5**	**28**	**13**	**87**	**2**	**13**
Zinc (mg)	14	78	4	22	9	60	4	27
Vitamin B6 (mg)	**13**	**72**	**4**	**22**	**10**	**67**	**2**	**13**
Vitamin B12 (mg)	13	72	5	28	11	73	3	20
Vitamin C (mg)	**12**	**67**	**2**	**11**	**13**	**87**	**2**	**13**
Vitamin K (mg)	0	0	8	100	2	13	12	80

Recommended Dietary Allowances (RDAs) in bold type and Adequate Intake (AIs) in ordinary type
*p=0.015

peers. These feeding problems were not correlated with other behavior clusters on the Child Behavior Checklist, with the exception of the Somatic Complaints factor. Similar feeding problems have been reported by others as well (Schreck and Williams 2006; Schreck et al. 2004a, Williams et al. 2005). While differences in types of foods accepted among children with autism and controls are reported by parents, this did not translate to clear patterns of nutritional deficits. Children with autism were not significantly different in their intake of total calories, carbohydrates, protein, or fats. However, children with autism ate fewer vegetables, and, thus, not surprising, had lower Vitamin K. Given the large standard deviations on both the FFQ and 24-h Dietary Recall Interview, we examined frequency of adequate versus inadequate intake based on DRIs. In examining individual differences in nutritional intake, children in both groups consumed adequate amounts of protein. Based on the FFQ, all the children in the autism group consumed adequate amounts of carbohydrates and protein. Seventy-nine percent of children with autism consumed adequate kilocalories which was the same as children in the comparison group. Over 50% of children in both groups had inadequate fiber intake. Hence, both groups of young children had low fiber diets. Inadequate iron was more frequent in the children with autism (26%) compared to controls (0%) based on the FFQ data. While this difference did not reach statistical significance, iron deficiencies in children with ASD have been reported by others (Dosman et al. 2006; Latif et al. 2002) and warrants further study given the importance of iron in developing children. Inadequate Vitamin K was suggested in 26% of the children with autism and in 0% of the controls which is not surprising given the limited vegetable intake. Much larger percentages of inadequate nutrition were evidenced based on the data from the 24 h Diet Recall Interview. This likely speaks to the variability of intake of children. While the FFQ asks more broadly about what a

child consumes, the 24 h Diet Recall Interview samples only one day (one data point). It should be again noted that none of the children in this sample were on any dietary restrictions. It is estimated that 15–27% of children with an autism spectrum disorder diagnosis are placed on a gluten and casein free diet (Levy and Hyman 2003). These children may very well have different nutritional profiles than the young children in our sample.

The small study offers some additional data in an area where there is a dearth of information. There are admittedly several limitations to the study. First of all, our sample size was small and limited our power to detect differences. Secondly, our measures are all parent based. A direct measure of food intake would be more optimal, such as was conducted by Ahearn et al. (2001). However, this methodology fails to account for the variability of food intake across several days, which is necessary to determine nutritional status. Given the variability we observed in this small sample, larger scales are sorely needed to further explore the extent of any nutritional deficits in children with autism. These studies should focus on young children, as this is the period when rapid growth is occurring and nutritional deficits may be more devastating. Finally, this is also the period where parents are still very much in control of their child's diet so changes may be more malleable.

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Appendix

FEEDING ASSESSMENT SURVEY

Child's Name	ID#
Person Providing Information	Date Completed

	Never	Sometimes	Often	Very Frequently
a. Throws food	0	1	2	3
b. Spits food	0	1	2	3
c. Cries, screams	0	1	2	3
d. Leaves the table before finished	0	1	2	3
e. Takes food from others	0	1	2	3
f. Refuses foods of certain texture	0	1	2	3
g. Refuses foods of certain color	0	1	2	3
h. Refuses foods of certain food group (vegetables, fruits, grains, protein)	0	1	2	3
i. Eats only a small amount	0	1	2	3
j. Eats too much	0	1	2	3

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