Published in final edited form as:
J Pediatr. 2010 August ; 157(2): 259–264. doi:10.1016/j.jpeds.2010.02.013.

Food Selectivity in Children with Autism Spectrum Disorders and Typically Developing Children

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Abstract

Objectives—To define food selectivity and compare indices of food selectivity among children with autism spectrum disorders (ASDs) and typically developing children, and to assess the impact of food selectivity on nutrient adequacy.

Study design—Food selectivity was operationalized to include food refusal, limited food repertoire, and high frequency single food intake using a modified food frequency questionnaire and 3-day food record. Food selectivity was compared between 53 children with ASDs and 58 typically developing children ages 3–11 years. Nutrient adequacy was assessed relative to the Dietary Reference Intakes.

Results—Children with ASDs exhibited more food refusal than typically developing children (41.7% vs. 18.9% of foods offered, $p < 0.0001$). A more limited food repertoire was reported for children with ASDs than typically developing children (19.0 vs. 22.5 foods, $p < 0.001$). Only four children with ASDs and one typically developing child were reported to demonstrate high frequency

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The authors declare no conflicts of interest.

single food intake. Children with a more limited food repertoire had inadequate intakes of a greater number of nutrients.

Conclusions—Our findings suggest that food selectivity is more common in children with ASDs than in typically developing children, and that limited food repertoire may be associated with nutrient inadequacies.

Keywords

food refusal; limited food repertoire; nutrient adequacy

Food selectivity or "picky eating" is often observed in young children and a frequent cause for parental concern. Food selectivity is more commonly reported in children with developmental disabilities than in typically developing children, particularly in children with autism spectrum disorders (ASDs).[1, 2] Despite numerous reports that focus on pickiness, rigidity, selective eating, and mealtime food refusals in children with ASDs,[3–7] a standardized definition of food selectivity is lacking. In addition, the relationship of food selectivity to nutritional adequacy is unknown. We sought to operationalize the definition of food selectivity, to compare food selectivity between typically developing children and children with ASDs, and to examine the relationship between food selectivity and nutritional adequacy.

Most studies of food selectivity in typically developing children have assessed whether a child is a picky eater based upon parental report, usually with a single question [8–13] or several items that tap specific picky/selective eating behaviors.[14–17] Direct measures of food intake have not previously been used to define picky eating. There is no standard operational definition for picky or selective eating.[8, 15, 16, 18]

These methodological problems extend to selective eating in children with ASDs. Parental and anecdotal clinical reports as well as a few research studies[2, 19] have suggested that children with ASDs have unusual eating habits. These are often described as overly selective, with aversions to specific textures, colors, smells, and temperatures and rigidity with respect to specific brands of foods. The term "food selectivity" has been used variously to refer to food refusal, decreased variety, and restricted intake to a few frequently eaten foods, with a variety of approaches employed to categorizing food, such as focusing on nutritional components (e.g., high protein, high starch) or sensory aspects (e.g., sticky, sweet). The lack of a standardized definition of food selectivity limits assessment or ability to compare across populations of children.

To address these gaps, we developed a definition of food selectivity based on our clinical experience and pilot studies that describe eating patterns of children with ASDs. We operationalized food selectivity to include three domains: 1) food refusal; 2) limited food repertoire; and 3) high frequency single food intake. We hypothesized that children with ASDs would exhibit more food selectivity than typically developing children and food selectivity would decline with age in typically developing children but would not be associated with age in children with ASDs. We also assessed whether food selectivity was associated with inadequate nutrient intake, given that this would have important implications for nutritional management.

Methods

Participants in the Children's Activity and Meal Patterns Study (CHAMPS) included children with ASDs and typically developing children ages 3–11 years. Participants were recruited via public listings on the Internet, outreach to local community programs (e.g., schools, YMCAs), existing participant databases at the UMMS-Shriver Center, autism support organizations, and

the assistance of the Interactive Autism Network (IAN) Research Database at the Kennedy Krieger Institute. Inclusion criteria included the child being in good health and free from diseases or disorders that could affect dietary and/or physical activity habits (e.g., diabetes, cystic fibrosis, chronic GI illness, cerebral palsy, etc.). We also excluded participants taking appetite-affecting medications, such as steroids, atypical antipsychotics, mood stabilizers, tricyclic antidepressants, anticonvulsants, and stimulants. The study was approved by the Institutional Review Board at the University of Massachusetts Medical School and written informed consent was obtained from the parents or guardians of the children who served as participants. Parents were reimbursed for their time, and children were given a gift certificate to a bookstore.

The diagnosis of autism in children with ASDs was confirmed via the Autism Diagnostic Interview-Revised (ADI-R).20 The Vineland Adaptive Behavior Scales (VABS) 21characterized adaptive skills and the Differential Abilities Scale (DAS)22 was administered to assess cognitive ability.

Children were weighed and measured in light clothing without shoes using a Seca™ (Hanover, MD) portable scale and wall-mounted stadiometer. Body mass index (BMI) was calculated from measures of height and weight (kg/m^2) and referenced against the sex- and age-specific CDC childhood growth reference.[23] Overweight was defined as a BMI-for-age at or above at the 85^{th} percentile, and underweight as less than the 5^{th} percentile, as recommended.[24]

Parents were interviewed about their child's dietary habits and use of special diets. Parents also completed a demographic/medical questionnaire and a modified food frequency questionnaire (FFQ), and were instructed by a registered dietitian or a nutrition graduate student to complete a 3-day food record on two weekdays and one weekend day. To capture food consumed at school, parents were provided a second food record and a letter to school personnel that explained the study and asked the child's teacher to record all the food eaten at school. In cases where children were capable of helping to keep the food record, both the parent and child were provided instruction. The completed food record was returned to the research team by mail and reviewed by a registered dietitian or a nutrition graduate student; any uncertainties were clarified by telephone with the parent.

Definition of food selectivity

We defined food selectivity to comprise three separate domains: 1) food refusal; 2) limited food repertoire; and 3) high frequency single food intake (HFSFI). Food refusal and HFSFI were assessed using a modified version of the Youth/Adolescent Food Frequency Questionnaire (YAQ).[25] Limited food repertoire was assessed using the 3-day food record.

Food frequency questionnaire—The YAQ was developed for self-administration with children and adolescents aged 9–18 years in the Growing Up Today Study25 and is based on the original Harvard Food Frequency Questionnaire.26 The YAQ has been shown to be reproducible and reliable.[27, 28] We modified the YAQ for parent (rather than child) report and to allow us to quantify how many foods children refused (food refusal) and whether children ate a large number of the same food(s) on a daily basis (HFSFI), as described in Table I. Our revised FFQ contained 131 food items in comparison with the original 126, and asked parents to write in foods that were not included on the FFQ if the child ate them at least once per week on average over the past year.

Food refusal—We assessed food refusal based on the absolute number of foods the parent indicated that the child would not eat, as well as the percentage of foods the child would not eat relative to the number of foods that were offered.

High frequency single food intake (HFSFI)—The highest two frequency categories on the FFQ were *4–5 times per day* and *more than 6 times per day*. We defined high frequency consumption as single foods on the FFQ list (or written in by the parent) that children ate more than 4–5 times per day. Beverages were not included in this measure because it is not uncommon to consume a beverage four or more times a day.

Limited food repertoire—Three-day food records were coded using Nutrition Data System for Research (NDSR, Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN) in an effort to determine each child's food repertoire, i.e., how many unique foods (including beverages) each child consumed over a three-day period (Table I). Nutrient inadequacy was based on the 3-day food record as analyzed for nutrient composition using NDSR software. The average level of each nutrient across the three recording days was determined for each child. To determine nutrient inadequacy of the child's diet, we identified nutrients that were found to be low in a nationally representative survey of the diets of US children29 or that have been reported to be low in studies of children with ASDs.4, 30 These included calcium, vitamins D and E, iron, zinc, and fiber. In addition, because intakes of vegetables and fruits are often below recommendations for US children,29 we included vitamins A and C in our analyses. We defined nutritional inadequacy relative to the estimated average requirement (EAR) for the specific life stage and sex group; for calcium,fiber, and vitamin D, for which an EAR has not been defined, we used the adequate intake (AI).[31] As a summary measure of nutrient inadequacy, we determined the number of nutrients (out of the eight we identified) for which the average intake was below the EAR or AI for each child.

Statistical Analysis

All analyses were conducted using SAS 9.1 (SAS Institute, Cary NC), with an alpha level of 0.05. Comparisons between typically developing children and children with ASDs were made using t-tests for continuous variables and chi-square or Fisher's exact tests for categorical variables. We evaluated the following variables to determine if they differed between children with ASDs and typically developing children: age; sex; race (white, non-white); following a special diet; parental education (college degree or not); siblings (none vs. 1 or more); and weight status (underweight, normal weight, overweight). For those variables that differed by group (ASD or typical), we assessed the need to control for potential confounding variables by determining whether they were also related to any aspect of food selectivity. We used Pearson correlation coefficients to assess the association between food refusal and limited repertoire, as well as the association of these aspects of food selectivity with age. We hypothesized that for typically developing children, food selectivity would decrease with age, whereas we did not expect to see an association with age among children with ASDs. We tested this hypothesis based on the statistical significance of the interaction (cross-product term) between age and group (ASD or typical) in linear regression models with food refusal and limited repertoire as outcome variables. We evaluated the relationship between food refusal and limited repertoire with nutrient inadequacy using Spearman correlation coefficients as well as linear regression.

Results

Fifty-three children with ASDs and 58 typically developing children completed the study (Table II). Mothers were the primary respondents, with 4 fathers in each group. Few of the characteristics differed between the two groups, except that children with ASDs were more likely to be on a special diet, and typically developing children were more likely to be an only child. Whether or not a child was an only child was not related to any aspect of food selectivity, however.

Food Refusal

We observed food refusal in both typically developing children and children with ASDs. On average, children with ASDs refused more foods and refused more foods as a percent of those offered than did typically developing children (Table III). In addition to all items on the FFQ, we evaluated vegetables separately; children with ASDs refused more vegetables than did typically developing children both in absolute amounts (11 ± 6 vs. 6 ± 5, $p < 0.0001$) and as a percentage of those offered (63% ± 31% vs. 33% ± 27%, $p < 0.0001$).

High frequency single food intake (HFSFI)

Contrary to our expectations, HFSFI was seen rarely among children in either group. Parents of only five children (four children with ASDs and one typically developing child) reported consumption at a level high enough to meet our definition of high frequency (i.e., consumption of a single food more than 4–5 times/day) (Table III). Parents of two children, both with ASDs, reported that their child consumed one food more than 6 times per day.

Limited food repertoire

Three-day food records were completed for 94% of children in the study; the parents of seven children (five with ASDs and two typically developing) did not record 3 days of intake and thus are not included in analyses related to limited repertoire or nutrient inadequacy. On average, parents of children with ASDs recorded that their child ate significantly fewer types of foods over the three day period than did typically developing children (Table III).

Inter-relationships among measures of food selectivity

We observed a significant inverse correlation between food refusal and food repertoire in the cohort ($r = -0.49$, $p < 0.0001$) and in each group (ASDs: $r = -0.53$, $p < 0.0001$; typically developing: $r = -0.34$, $p = 0.01$). As expected, children with broader food repertoires refused fewer foods as a percentage of those offered than children with more restricted food repertoires.

The correlation (r) overall between food refusal and age was −0.12 ($p = 0.21$), and was −0.24 ($p = 0.08$) and −0.001 ($p = 0.99$) in children with ASDs and typically developing children, respectively. The correlation between limited repertoire and age overall was $r = 0.03$ ($p = 0.77$), and was 0.19 ($p = 0.19$) in children with ASDs and $r = -0.13$ ($p = 0.36$) in typically developing children.

In addition, contrary to our hypothesis, the association between food selectivity and age did not depend upon whether the child had an ASD or was typically developing (interaction with age: p-value = 0.12 for food refusal, and $p = 0.11$ for limited food repertoire).

Nutrient inadequacy and food selectivity

When looking at both groups together, of the eight nutrients we considered to be at possible risk of inadequate intake, the median number of nutrients for which children were below the EAR or AI was three. With the exception of one child, all children in the cohort had an inadequate intake of fiber. Twelve children were inadequate on five or more nutrients. In addition to fiber, nutrient inadequacy was common for vitamin D, vitamin E, and calcium. Inadequate intakes of vitamin D and calcium were more frequent for children with ASDs compared with typically developing children (Table IV). Overall, children with ASDs had a greater number of nutrients for which intake was inadequate compared with typically developing children ($p = 0.03$). When children on special diets were excluded, the results were essentially unchanged (not shown).

In order to explore which aspects of food selectivity were associated with nutrient inadequacy, we examined the association between food refusal and limited repertoire with nutrient inadequacy. We found that food refusal was not significantly associated with nutrient inadequacy in the cohort overall ($r = 0.13$, $p = 0.20$; linear regression $R^2 = 0.02$), nor was there evidence that the association between food refusal and nutrient inadequacy differed for the ASD and typical groups ($p = 0.32$ for interaction). By contrast, limited repertoire was associated with greater nutrient inadequacy in the cohort overall ($r = -0.33$, $p = 0.0006$; linear regression $R^2 = 0.13$). Although children with ASDs and typical children differed in their food repertoire, there was no evidence to suggest that the association between limited food repertoire and nutrient adequacy depended upon on whether the child had an ASD or was typically developing ($p = 0.82$ for interaction). Exclusion of the children who were following special diets did not substantively affect the observed associations (results not shown).

Discussion

We found that children with ASDs displayed more food refusal and exhibited a more limited food repertoire than did typically developing children, although food refusal was present in both groups of children. The commonly held belief that dietary "pickiness" is outgrown with age was not supported by our cross-sectional findings. We found that among typical children, levels of food refusal and food repertoire were similar by age, whereas among children with ASDs, food refusal, but not food repertoire, was marginally lower among older children. The lack of statistical significance for the test of the interaction term and the cross-sectional nature of our study preclude any conclusions with regard to the association of food selectivity measures and age.

Although anecdotal reports suggest that some children with ASDs consume a certain food or foods nearly exclusively, we did not observe this phenomenon in our sample. Parents of only four of 53 children with ASDs (7.5%) reported that their child consumed a single food more than 4–5 times per day. This suggests that HFSFI does not occur as commonly in children with ASDs as might be assumed based on anecdotal reports. However, the operational definition of HSFSI chosen for this study may have masked some of the unique eating habits of children with ASDs. For example, if a child ate macaroni and cheese for breakfast, lunch, and dinner (three times daily) this behavior would not have met our definition of HFSFI, although most would consider this eating pattern to be unusual. However, we did not observe this in our 3-day food records.

The association between limited repertoire and nutrient inadequacy suggests that a very limited diet may put any child at risk for nutritional deficiencies.[4, 30] We found that children who had a narrower food repertoire were more likely to have inadequate intake of more nutrients. We chose to use the EAR,[31] which is the nutrient intake needed to meet the estimated requirement of about 50% of the population, where one was available. In the absence of an EAR, we used the AI. We saw associations between nutrient inadequacy and limited food repertoire but not with food refusal. This discrepancy may be explained by the fact that food refusal was determined from the FFQ and nutritional adequacy from the 3-day food record. The FFQ assesses usual intake over the previous 12 months; limited food repertoire and nutrient inadequacy were both based on the same dietary assessment tool, i.e., a food record which covered 3 days of intake.

Gluten-free/casein-free and lactose-free diets are followed by some children with ASDs. Because children who adhere to these diets restrict all dairy products, their calcium and vitamin D intakes would be expected to be low. In this scenario, these children's food intakes would reflect parental restriction rather than the children's food selectivity. However, the observation that the association between food selectivity and nutrient inadequacy did not differ by autism

status, even after excluding children on special diets, suggests that our observations did not reflect parental restriction.

We acknowledge several limitations in our study. Our methodology for determining food refusal and HFSFI was based on a modified FFQ. Because a parent may not offer a food that he/she believes the child would refuse, we cannot determine whether not offering a food is influenced by the child's presumed or historical refusal of that food. We observed a great deal of variability in the number of foods that were not offered to children, which was greater among children with ASDs (range of 0 to 90 foods not offered, compared with a range of 3 to 46 foods not offered to typically developing children). Among the children with ASDs, being on a special diet was associated with more foods not being offered but not with percent of foods refused of those offered. Thus, some parents of children with ASDs offered a limited number of foods; this would preclude the child refusing those foods. Additionally, we disaggregated all fruit and vegetable items but not other aggregated foods listed in the FFQ, based on our understanding that fruits and vegetables are commonly refused and our desire to be able to accurately estimate refusal of these foods. However, aggregated entrees (such as "meatballs or meatloaf" or "roast beef or ham sandwich") and grains (such as "English muffins or bagels") were left together, in order to minimize participant burden. This could introduce error in our measures of refusal.

Another limitation with our measurement of food repertoire was that the food record only captured three days of intake, which may not adequately capture the variety of the typical diet. However, Falciglia et al[32] compared a 3-day record with a 15-day record in children and found that the 3-day was accurate for assessment of variety in children, although more precise estimates were found when they used three non-consecutive days. We also made coding decisions that may have affected our estimate of variety. Participants reported eating approximately 900 different foods overall, so decisions about coding of food often required that we collapse several items into one group. We based our coding decisions on the structure of the NDSR software. For example, all breads were considered a single food, which means that white bread, whole wheat bread, and banana bread would all be considered bread. Although we instructed parents to report sandwiches by their ingredients, some did not, requiring the sandwich to be considered a single food. Any errors introduced in this way would be expected to affect both groups similarly.

Generalizability is an issue in all observational studies. Parents who describe their children as picky eaters are often concerned that their child's lack of variety prevents them from getting optimum nutrition, and thus could be disproportionately attracted to a study like ours. In order to limit ascertainment bias, we developed recruitment materials that described our study purpose as understanding the mealtime and activity patterns of children with and without autism, without regard for whether parents had concerns in these areas. However, it is possible that parents of children with unusual eating patterns may have been more interested in participating in the study.

Our study operationalizes the definition of food selectivity and provides data from a moderate-sized sample that supports the notion that food selectivity is more common in children with ASDs than in typically developing children. Further, we have shown that one aspect of food selectivity—limited food repertoire—is associated with inadequate intake of nutrients. These findings, if confirmed, suggest that limited repertoire may be of concern. Future research is needed to determine the antecedents to food selectivity as well as to develop interventions that will increase food repertoire and decrease food refusal in children with ASDs. Longitudinal studies examining food selectivity are needed to understand whether food selectivity persists into adolescence and adulthood, the impact of prolonged food selectivity on nutritional status,

and whether there are differences in persistence of this phenomenon between children with ASDs and typically developing children.

Acknowledgments

Supported by NIH grants R21 HD048989, 2P30HD004147-33A2, and 5P30DK046200-14.

List of abbreviations

ASDs	autism spectrum disorders
HFSFI	high frequency single food intake
CHAMPS	Children's Activity and Meal Patterns Study
IAN	Interactive Autism Network
ADI-R	Autism Diagnostic Interview-Revised
VABS	Vineland Adaptive Behavior Scales
DAS	Differential Abilities Scale
BMI	body mass index
FFQ	food frequency questionnaire
YAQ	Youth/Adolescent Questionnaire
NDSR	Nutrition Data System for Research
EAR	estimated average requirement
AI	adequate intake
RDA	recommended dietary allowance

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Table 1

Domains and Definitions of Food Selectivity

Domain	Definition	Source of data
Food refusal	# of foods the child will not eat % of foods the child will not eat of those offered	Modified FFQ*
Limited food repertoire	# of unique foods consumed over a 3-day period	3-day food diary†
High frequency single food intake	Single foods eaten 4–5 or more times daily	Modified FFQ*

*We used the 9 frequency categories from the original Harvard Food Frequency Questionnaire, so that all the foods would have the same frequency options. We added a category: *N/A Don't Offer* (not applicable, food item is never offered to the child), and we split the category *never/less than once a month* into two separate categories: *Never – Will Not Eat* (child refuses the food item) and *Less than one time per month*. Fruits and vegetables that were combined in a single item on the original Youth/Adolescent Food Frequency questionnaire (e.g., "oranges and grapefruits," "peas and lima beans") were listed separately.

†NDSR output lists all of the foods each child ate at the whole-food level in the 3-day period. Similar foods were grouped together to prevent foods with similar taste, texture, and appearance, such as French fries and tater tots, from being counted as two separate foods. To create groups, we first collapsed all foods according to their NDSR identifying names and then eliminated all ingredients. Foods not in the NDSR database, including generic foods and some brand name foods, were included with their groups or identical foods to prevent counting identical foods twice. In total, there were approximately 900 different foods consumed by the participants.

Table 2

Demographic characteristics in children with autism spectrum disorders and typically developing children

	Typically Developing Children (n=58)	Children with ASDs (n=53)	P value*
Age, years: Mean (SD)	6.7 (2.4)	6.6 (2.1)	0.75
VABS Score: Mean (SD)	N/A	71.1 (12.4)	
DAS General Conceptual Ability Score: Mean (SD)	N/A	85.8 (22.1)†	
Sex, male (%)	78%	83%	0.47
Race, white (%)‡	76%	83%	0.35
Maternal education, ≥ college degree (%)	72%	74%	0.89
Paternal education, ≥ college degree (%)	67%	54%§	0.15
One or more parent with college degree (%)	81%	81%	0.99
Child is an only child (%)	26%	11%	0.05
Child is on a special diet (N)‖	0	11	<0.001
Overweight, ≥ 85th percentile BMI (%)	22%	26%	0.62
Underweight, BMI < 5th percentile BMI (%)	0%	1.9%	0.48

*P values for differences in autism status groups

†n=47; There were 6 subjects for whom DAS GCA scores were not available: 2 subjects took the DAS at a level where a GCA is not calculated; 1 subject refused testing; and 3 subjects had problems with test administration such that their tests could not be scored.

‡Racial/ethnic breakdown for non-white participants: Black/African-American: 7% typically developing, 2% ASDs; Hispanic: 5% typically developing, 4% ASDs; Asian: 0% typically developing, 4% ASDs; More than 1 race/other: 12% typically developing, 8% ASDs

§n=52

‖Special diet = gluten/casein free, wheat free, or lactose free. Nine children were on a gluten-free/casein-free diet. One child was on a wheat-free diet, and one child was on a lactose-free diet.

Table 3

Food Selectivity in children with autism spectrum disorders and typically developing children

	N	Typical children	N	Children with ASDs	P value*
Food refusal†: Mean (SD)					
Number of FFQ items will not eat	58	21 (18)	53	45 (26)	<.0001
Percentage of FFQ items will not eat of those offered‡	58	18.9% (15.6%)	53	41.7% (21.2%)	<.0001
Limited repertoire§: Mean (SD)	56	22.5 (4.6)	48	19.0 (5.0)	0.0003
High frequency single-food intake//: n (%)	58	1 (1.7%)	53	4 (7.6%)	0.19

*P value is for difference between children with ASDs and typically developing children.

†For food refusal, minimum, median, maximum, number of foods refused for typical children was 0, 16, 79, and for children with ASDs was 1, 47, 94. The minimum, median, and maximum percent of foods refused of those offered was 0%, 14%, 62% for typical children and 1%, 41%, 74% for children with ASDs.

‡Number of foods will not eat of those offered is the percentage of foods that the child would not eat relative to the number of foods that were offered.

§Food repertoire was the number of foods eaten over a three day period.

//Number of children eating a food more than 4.5 times a day.

Table 4

Frequency of nutrient inadequacy in children with autism spectrum disorders and typically developing children

# (%) not meeting EAR*/AI† for specific nutrients	Typically developing children (n=56)‡	Children with ASDs (n=48)	P value§
Vitamin A	0 (0.0%)	5 (10.4%)	0.02
Vitamin C	5 (8.9%)	10 (20.8%)	0.10
Vitamin D	31 (55.4%)	38 (79.2%)	0.01
Vitamin E	41 (73.2%)	30 (62.5%)	0.29
Zinc	3 (5.4%)	5 (10.4%)	0.47
Calcium	24 (42.9%)	31 (64.6%)	0.03
Iron	0 (0.0%)	0 (0.0%)	NA
Fiber	56 (100%)	47 (97.9%)	0.46
# (%) nutrients inadequate			
0 nutrients	0 (0%)	0 (0%)	
1 nutrient	3 (5.4%)	3 (6.3%)	
2 nutrients	20 (35.7%)	5 (10.4%)	
3 nutrients	19 (33.9%)	21 (43.8%)	
4 nutrients	10 (17.9%)	10 (20.8%)	
5 nutrients	4 (7.1%)	5 (10.4%)	
6+ nutrients	0 (0.0%)	4 (8.3%)	
			0.03//

*EAR is estimated average requirement

†AI is adequate intake

‡7 children (5 with ASDs, 2 typical) did not have complete 3-day food records and are not included in this table.

§P values are for differences between children with ASDs and typically developing children.

//P value is from a Fisher's exact test with 11 degrees of freedom.