

## Nutrient Intake among Children with Autism

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### Abstract

The objective of this study was to examine adequacy of nutrient intake and determine the impact of multivitamin use on nutrient intake in children with autism. This was a retrospective analysis of food frequency questionnaire data collected from 54 children, ages 2-8 years, in the Autism Integrated Metabolic and Genomic Endeavor Study at Arkansas Children's Hospital Research Institute, Little Rock, AR. The average percent of Kilocalories from carbohydrate, protein and fat fell within the acceptable macronutrient distribution ranges at 56%, 14% and 33%, respectively. Mean intakes for calcium, potassium, vitamin E, vitamin D and fiber were below the dietary reference intake (DRI) levels at 75%, 57%, 77%, 25% and 41%, respectively. Mean intakes of vitamin A, thiamin, riboflavin, vitamin C, and vitamin B6 exceeded the DRI at 216%, 233%, 270%, 452% and 228%, respectively. No differences were found in vitamin D, vitamin E, calcium, total kilocalorie, carbohydrate, protein and fat intake between children who were multivitamin users and those who were non-users. These data indicate that children with autism have diets adequate in kilocalories and macronutrients, while imbalances exist in fiber and several micronutrients. Dietary interventions for children with autism should be aimed at addressing these potential nutritional imbalances.

**Keywords:** Autism; Autistic disorder; Children; Dietary intake; Nutritional status; Food frequency questionnaire

**Abbreviations:** DRI: Dietary Reference Intake; AMDR: Acceptable Macronutrient Distribution Range; FFQ: Food Frequency Questionnaire; Autism IMAGE Study: Autism Integrated Metabolic and Genomic Endeavor Study; GI: Gastrointestinal; ASD: Autism Spectrum Disorders; AD: Autistic Disorder

### Introduction

Autism spectrum disorders (ASDs) are a group of complex neuro-developmental disorders characterized by impairments in social and communication skills as well as repetitive body movements and behaviors [1]. ASDs include autistic disorder (AD), Asperger's syndrome and pervasive developmental disorder - not otherwise specified. The most recent estimates from the Centers for Disease Control reveal that one in 88 children in the United States have some type of ASD [2]. This represents a marked increase since 2000 when prevalence rates were approximately one in 150 children [2]. Boys are disproportionately affected with rates approximately five times higher than girls (1:54 boys versus 1:252 girls) [2]. The exact cause for the increased rate is unknown but may be due, in part, to increased awareness and availability of services resulting in more ASD diagnoses.

Children with ASDs often exhibit behaviors that result in feeding problems and, in turn, may impact nutrient intake. They tend to desire sameness in daily routines including eating the same foods that result in a diet that lacks variety [3]. Additionally, disturbances in routine may lead to disruptive mealtimes, and, thus poor intake.

Other possible factors that may affect nutritional status include gastrointestinal (GI) complications as well as differences in metabolism and utilization of nutrients.

GI complaints are common among children with ASDs. Diarrhea, foul smelling stools, flatulence, abdominal pain and constipation are among the most commonly reported GI problems [4]. Adams et al. [5] found that children with more severe cases of AD reported more GI symptoms.

Researchers have begun to explore metabolic abnormalities that may be present in children with ASDs [6-10]. Specifically, imbalances of some metabolic biomarkers related to oxidative stress and DNA methylation have been noted. James et al. [6,7] reported decreases

in methylation and antioxidant capacity with subsequent increases in oxidative stress in children with AD. Similarly, Melnyk et al. [10] found decreased antioxidant and methylation capacity in children with AD (n = 68) when compared to groups of unaffected siblings (n = 40) and controls (N = 54). Increased oxidative stress in children with AD can lead to cellular damage and altered epigenetic expression. Thus, exploring these imbalances and investigating nutritional interventions that may normalize these metabolic pathways may be a critical component in treating AD.

These potential factors affecting nutritional status make it imperative to examine the adequacy of nutrient intake in children with AD. Few studies have compared food and nutrient intake of children with AD to children with typical development or to standard values. Thus, the purpose of this study was to determine adequacy of nutrient intake in children with AD and to examine if multivitamin use affected nutrient intake levels.

### Materials and Methods

Data analyzed for this study were a subset of fifty-four children who participated in the Autism Integrated Metabolic and Genomic Endeavor (IMAGE) Study, an on-going, case-control study at Arkansas Children's Hospital Research Institute, Little Rock, AR. The study was approved by the Institutional Review Board at the University of Arkansas for Medical Sciences.

Inclusion criteria for children to participate included that they be 3-10 years of age and have a diagnosis of AD. Exclusion criteria for the study included: 1) diagnosis of Asperger's syndrome or pervasive developmental disorder-not otherwise specified, 2) diagnosis of a

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single gene or chromosomal disorder, 3) use of anti-folate medications, 4) use of high dose vitamins, nutritional or herbal supplements, and 5) use of other medications known to interfere with the study's results or scientific validity as determined by the principal investigator.

Data collected at the study visit included height and weight measurements according to standardized procedures and caregivers were queried about the child's use of supplements. Additionally, a validated food frequency questionnaire (FFQ), Block Kids 2-7 FFQ (Nutrition Quest, Berkeley, CA, USA), was administered by the study coordinator [11]. Analyses of all essential nutrients were compared to the dietary reference intake (DRI) values and acceptable macronutrient distribution ranges (AMDR) to determine dietary adequacy.

## Statistics

Data were analyzed using IBM SPSS, version 19.0, statistical database software (Armonk, New York, USA). Descriptive statistics, including means and standard deviations, were used to describe study variables. One-way between groups multivariate analysis of variance (MANOVA) was performed to investigate multivitamin use with dietary intakes of vitamin D, vitamin E and calcium, and to explore the impact of multivitamin use on macronutrient intake.

## Results

Analyses were conducted on 54 children (47 males, 7 females). The uneven gender distribution reflects the increased prevalence of AD in males [2]. The age and ethnic distribution of the children is summarized in Table 1. Height and weight measurements were recorded on 39 children from which body mass index (BMI) was calculated. Children's BMI categories are presented in Table 2 and are based on the Centers for Disease Control weight classifications for children ages 2-20 [12]. Twenty of the children (37%) were taking over-the-counter multivitamin supplements and 34 (63%) were not taking supplements.

### Macronutrient intake

Mean daily intake of kilocalories was 1,511 (SD = 524.8). The mean intakes of carbohydrate, protein and fat grams were 211 grams (SD = 84.7), 51 grams (SD = 19.2), and 55 grams (SD = 18.5), respectively. A mean of 56% kilocalories came from carbohydrate (SD = 6.9), 14% from protein (SD = 3.2) and 33% from fat (SD = 5.0). The mean intake of dietary fiber was 10 grams (SD = 5), reflecting 41% of the DRI (SD = 19). No significant difference between multivitamin users and non-users was found for the combined macronutrients (carbohydrates, protein, fat and total kilocalories),  $F(4, 49) = 2.30, p = .072$ ; Wilks' Lambda = .84; partial eta squared = .16.

### Micronutrient intake

Average nutrient intake was below 100% of the DRI for calcium (75% DRI, SD = 45), potassium (57% DRI, SD = 22), vitamin E (77% DRI, SD = 26), and vitamin D (25%, SD = 19). The average intake of vitamin A, thiamin, riboflavin, vitamin C, and vitamin B6 exceeded the DRI at 216% (SD = 110), 233% (SD = 81), 270% (SD = 109), 454% (SD = 282) and 228% (SD = 86), respectively. Using one-way between groups MANOVA results for the combined micronutrients (vitamin D, vitamin E and calcium) showed no significant difference between children who took multivitamins and those who did not take multivitamins,  $F(3,50) = 1.27, p = .294$ ; Wilks' Lambda = .93; partial eta squared = .07.

## Discussion

Results of this study reveal that children with AD have diets adequate

Age (years)	Males (n=47)			Females (n=7)		
	Ethnicity					
	White <sup>a</sup>	Black <sup>b</sup>	Other <sup>c</sup>	White <sup>a</sup>	Black <sup>b</sup>	Other <sup>c</sup>
3	5	3	0	0	0	0
4	9	0	1	4	2	0
5	11	0	1	0	0	0
6	5	1	1	1	0	0
7	9	0	0	0	0	0
8	1	0	0	0	0	0
Total	40	4	3	5	2	0

Note: <sup>a</sup>White, Non-Hispanic; <sup>b</sup>Black, Non-Hispanic; <sup>c</sup>Other – 1 child was Asian and 2 children had a mixed racial background

Table 1: Number of Children according to Ethnicity by Gender and Age (N=54).

Age (years)	Males (n=34)				Females (n=5)			
	BMI Category							
	UW <sup>a</sup>	NW <sup>b</sup>	OW <sup>c</sup>	OB <sup>d</sup>	UW <sup>a</sup>	NW <sup>b</sup>	OW <sup>c</sup>	OB <sup>d</sup>
3 (n=6)	0	4	0	2	0	0	0	0
4 (n=13)	1	5	0	2	1	4	0	0
5 (n=10)	0	6	2	2	0	0	0	0
6 (n=6)	0	3	2	1	0	0	0	0
7 (n=3)	0	1	1	1	0	0	0	0
8 (n=1)	0	0	0	1	0	0	0	0
Totals	1	19	5	9	1	4	0	0

<sup>a</sup>UW = under-weight with BMI for age <5%; <sup>b</sup>NW = normal weight with BMI for age 5.0-84.9%; <sup>c</sup>OW = overweight with BMI for age 85.0-94.9%; <sup>d</sup>OB = obese with BMI for age ≥95%

Table 2: Number of Children per BMI Category by Gender and Age (N= 39).

in kilocalories and macronutrients; however, some micronutrients are under- or over-consumed. Our findings are similar to reports from other researchers [3,13-15]. Edmond et al. [3] reported adequate energy intake and growth in children with ASD, although their diets were less varied when compared to a group of control children.

Although average intakes for the macronutrients were within the AMDR in the present study, some individual differences are worth noting. Eleven children (20%) exceeded the AMDR for fat, consuming >35% of kilocalories from fat. Similarly, Raiten and Massaro [16] reported increased fat intake among children with AD. Furthermore, Curtin et al. [17] reported the prevalence of obesity in children with autism to be 30.4% compared to 23.6% in children without autism. These findings highlight the importance of on-going nutrition assessment in children with AD so that early dietary interventions can be implemented to prevent obesity and related health problems.

We found intakes below the DRI for calcium, potassium, vitamin E, vitamin D and fiber. These data are similar to findings from other studies [13-16]. In the present study, vitamin D intake averaged only 25% of the DRI. These low levels may warrant further investigation since recent reports suggest vitamin D deficiency, especially in utero and early childhood, may be related to increased risk of autism [18]. Vitamin D has been shown to increase glutathione levels, thus increasing antioxidant capacity [19-20]. Therefore, deficiencies may alter glutathione metabolism and be a factor in the pathology of AD.

Dietary fiber intake averaged 41% of the DRI in the present study. Constipation is one of the most common complaints among children with autism [4]. Ibrahim et al. [21] found that children with AD had a higher cumulative incidence of constipation compared to children without AD (33.9% versus 17.6%). Adequate dietary fiber intake may

	*MVI Users (n = 20)		*MVI Non-Users (n = 34)	
	Mean	SD	Mean	SD
Total Kilocalories	1689	614	1406	441
Carbohydrates (g)	240	99	193	71
Protein (g)	55	22	49	17
Fat (g)	61	21	51	16

Note: \*MVI = Multivitamin

**Table 3:** Means and Standard Deviations for Total Kilocalories and Macronutrients of Multivitamin Users and Non-Users.

alleviate this problem and should be emphasized when providing nutrition recommendations to children with AD and their caregivers.

It should be noted that low levels of calcium, vitamin E, vitamin D, and fiber have also been reported in children with typical development [13]. Thus, suboptimal intake of these nutrients may not be unique to children with AD. However, they are important factors to consider and address when assessing the nutritional status of this population.

We found several micronutrients including vitamin A, thiamin, riboflavin, vitamin C, and vitamin B6 were consumed in levels exceeding the DRI. This may be due to the higher consumption of enriched foods and fruit juices commonly consumed by children with AD. Other researchers have reported increased intakes of vitamin C [16] and vitamin B6 [13] in this population, as well.

No statistically significant differences were found in nutrient intake between children taking over-the-counter multivitamins and those not taking multivitamins. However, multivitamin users had slightly higher mean intakes of total Kilocalories, carbohydrate, protein and fat when compared to non-users (Table 3).

## Limitations

This study was limited to children in Arkansas. Future studies examining dietary factors of children with AD in other geographic regions would add to the literature. Additionally, studies comparing nutrient intake of children with AD to children with typical development would aid in developing specific dietary recommendations for children with AD.

## Conclusion

Several factors may influence the nutritional status of children with AD including feeding problems, GI issues and metabolic abnormalities. Our results support previous findings that children with AD under- and over-consume some nutrients. Dietary interventions for children with autism should be aimed at addressing these potential nutritional imbalances.

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