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Analysis of Dietary Intake in Children with Autism Spectrum Disorder

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Abstract

Parents and caregivers of children with Autism Spectrum Disorder (ASD) often report that their children are picky, restricted, and problem eaters. Additionally, it has been reported that children with ASD often experience gastrointestinal problems such as constipation, diarrhea, flatulence, cramping, bloating, and diffuse pain. These factors raise concern for nutritional status of children with ASD, given that the refusal to consume particular foods coupled with the inability to tolerate, digest, and absorb these foods can compromise an individual's overall nutrition status. The aim of our study was to evaluate dietary intake in a group of 120 children aged 2-14 years who were served in an outpatient clinic over 18 months' time. Anthropometric data and 3-day food diaries were collected and evaluated by a licensed, registered dietician. The results indicate that the majority of participants consumed adequate calories, protein, fats, and carbohydrates. However, the majority of participants were deficient in vitamins A, D, B1, and folate, as well as calcium, magnesium, iodine, and potassium. Essential fatty acid intake was insufficient for all but 6 of the participants. Overall, the study revealed deficits in several key nutrients for the majority of participants.

Keywords: Autism; Nutrition; Diet; Macronutrient; Micronutrient; Vitamin

Introduction

Autism Spectrum Disorder (ASD) is a developmental disability typically diagnosed by the age of 3 years. ASD defined by DSM-5 criteria includes impairments in social interaction and communication, repetitive and stereotyped behaviors, and early onset (prior to the age of 3) of symptoms [1]. The most current Centers for Disease Control and Prevention (CDC) estimates for ASD in the United States population, based on children born in 2002, indicated that approximately 1 in 68 children aged 8 years met the criteria for this diagnosis. The CDC found that boys were nearly 5 times more likely to receive this diagnosis than girls, indicating that approximately 1 American boy in 42 is currently diagnosed with ASD. These figures come from the Autism and Developmental Disabilities Monitoring (ADDM) Network monitoring data collected in 2010. This prevalence has increased from the estimates of 1 in 2,000 children noted from the 1940s through the 1980s in various publications [2].

Recent research highlights the incidence of food refusal, feeding selectivity, and other concerns in this population [3-5]. Many children with ASD have strong preferences for specific food types and aversions to others. Parental reports and research have established that children with ASD will gravitate toward foods of certain textures, colors, and temperatures, and specific food groups [6]. Additionally, children with ASD are known to experience a variety of gastrointestinal symptoms and concerns with at least the same prevalence as children without ASD [7]. These symptoms, as reported by parents and professionals, include gastroesophageal reflux (GERD), diarrhea, constipation, flatulence, and abdominal cramping and distention. Food refusal and selectivity, coupled with potential gastrointestinal concerns, are likely to place an individual at risk of nutrient insufficiency [7-11].

The issue of dietary intake and resulting nutritional status in children with ASD has not been well studied. Vitamin and mineral deficiencies associated with food selectivity in children with ASD have been identified in the literature in recent years, though results remain mixed. Sharp et al published a meta-analysis review in 2013, which provides a quality summary of the available research on this topic to date [6]. For this reason, we chose to evaluate dietary intake in children with autism in conjunction with Dietary Reference Intake (DRI) as recommended by the Institute of Medicine. The aim of this study was to determine dietary nutrient status in children with ASD.

Method

The procedures followed were in accordance with the ethical standards of the responsible institutional or regional committee on human experimentation or in accordance with the Helsinki Declaration of 1975 as revised in 1983. This study was approved by the Austin Multi-Institutional Review Board and written informed consent was obtained from the parent or legal guardian of all children who participated in the study. Participants in this study included children diagnosed with ASD seeking dietetic and nutrition support through an outpatient pediatric clinic over an 18-month time frame between January 2009 and June 2010. Some families initiated care and treatment services without referral, and some were referred from other practitioners for dietetic and nutrition assessment and care. Exclusion criteria included those with a history of major chronic disease, those who had used medication known to affect growth or nutritional status at any time, and those on a current elemental diet (a therapeutic intervention that contains nutrients as small molecular weight compounds).

All children included in this retrospective analysis had received an ASD diagnosis prior to initiation of services. These diagnoses were verified with copies of the original assessments provided to the clinic at

the time of service initiation. All formal diagnostic assessments were completed by appropriately trained clinicians, including psychologists, psychiatrists, developmental pediatricians, or neurologists. The children met the criteria for an ASD diagnosis based on the criteria as outlined in the DSM-IV regarding age of onset, repetitive, stereotypical behavior, and significant deficits in social interaction and communication [12]. There were 512 subjects who met the study inclusion criteria. The parents were subsequently contacted by mail, which included a description of the study and the study informed consent form (ICF). Due to a limited response to the first mailing, a second round of ICFs was mailed to non-responders. Families were then contacted via phone to review the ICF with a study coordinator. Out of these 512 subjects, 132 agreed to have their child participate in the study. If a parent consented to having their child participate but the necessary information was not found in the child's medical record, that subject was excluded from the study. The final study included a total of 120 subjects, including 108 male and 12 female participants, aged 14 (Table 1).

The clinical charts of all subjects were reviewed. Patients served by this practice provide extensive background information, including diagnostic, educational, and medical information as an initial component of care. The medical history, dietary information, and anthropometric data required for the study was extracted from each file.

Parents provided detailed dietary information concerning their child's dietary consumption over a 3-day time frame. Two of the days were weekdays and one was at the weekend. This requirement is set to establish typical dietary intake over a variety of settings such as day care, school, and home. Days reported on the 3-day diet paperwork were not required to be contiguous, particularly if a child was ill or if the child's environment had been disrupted or was unusual while collecting dietary data. Parents were given detailed instructions developed by a licensed, registered dietician for collecting accurate data for the purpose of a food diary analysis, with additional training and instructions providing information on quantifying portion sizes and estimating ingredients. A licensed, registered dietician was available for questions throughout the course of this data collection. Children consuming dietary and nutritional supplements were included in the study, but any nutrient values associated with those supplements were not included. Additional information collected at the time of this appointment included anthropometric data, vital statistics, health and medical history, and feeding behavior/habits, but these are not reported here.

Age (yrs)	Sex	N	Energy (kcal)			Protein (g)			Carbohydrates (g)			Calories from fat (kcal)		
			Mean	Range	%	Mean	Range	%	Mean	Range	%	Mean	Range	%
2-3	Both	27	1413.3	1000.0-2629.0	141.33	50.22	21.9-90.7	392.26	191.94	65.5-418.8	191.94	463.86	307.6-726.2	142.73
4-8	Both	72	1689.5	689.8-3496.8	122.69	61.73	17.9-131.4	416.32	220.29	83.1-436.8	220.29	581.23	149.7-1856.1	140.61
9-13	F	6	1842.5	1123.3-2677.5	115.15	79.6	29.3-163.0	226.71	201.93	107.0-272.7	201.93	752.42	386.5-1690.5	156.75
14	F	1	1655.2	1655.2-1655.2	91.95	117.55	117.6-117.6	486.96	160.27	160.3-160.3	160.27	534.43	534.4-534.4	98.97
9-13	M	12	2116.8	1381.8-2920.6	117.6	69.1	29.8-159.2	251.99	282.19	183.3-367.0	282.19	745.97	442.4-1276.2	138.14
14	M	2	2199.1	1476.7-2921.4	99.96	116.42	44.8-188.0	324.39	179.23	136.7-221.8	179.23	1059.9	447.6-1672.3	160.6

Table 1: Macronutrient status by age and gender.

Information gathered through the 3-day food diary was used to calculate total caloric intake and macro/micronutrient status, via analysis using the ESHA Food Processor SQL Diet and Nutritional Analysis Software program (version 10.3.0, 2008, ESHA, Salem, OR). Estimated energy requirement for each patient was derived from height, weight, and appropriate physical activity level using the formulas developed by the Institute of Medicine. These values were then converted to DRIs as necessary, based on age- and gender-normalized DRIs. For each dietary element, adequate intake was defined as greater than or equal to 100%, borderline intake was defined as 80-99%, and inadequate intake was defined as less than 80% of the DRI.

Anthropometric data was collected by a licensed, registered dietitian using a wall-mounted Detecto stadiometer measurement instrument with a moveable measuring rod and a Detecto physician model standard balanced beam weight scale. Anthropometric measurements also included triceps skinfold thickness (TSF), mid-arm circumference (MAC), and mid-arm muscle circumference (MAMC) measured with standard steel precision calipers for use with pediatric patients. Accuracy of all instruments was verified before use.

Dietary intake for 3 days was obtained for each participant. Usual dietary intakes were estimated by combining each of the three days using the Multiple Source Method (MSM) [13,14]. The MSM estimates intake in three steps: (1) the probability of a putative nutrient on a random day is assessed, (2) the usual amount of the intake for a consumption day is estimated, and (3) the values from the prior two steps are multiplied to obtain the usual dietary intake.

Data were analyzed by computing whether each usual dietary intake was meeting adequate levels and classified as either adequate if so, or classified as not adequate if nutrient levels were in the inadequate or borderline region. Frequencies and percentages of the number of children in each classification are presented in tables below.

Results

The total macronutrient intake of all 120 participants with ASD is summarized in Table 2. Macronutrient consumption was appropriate for the majority of children: 96 (80%) children with ASD consumed an adequate amount of total calories each day, whereas only 24 (20%) children consumed an inadequate or borderline amount of total calories. On balance, protein energy needs were met for the majority of study participants: 118 (98.33%) children consumed adequate protein calories each day, with only 2 (1.67%) children consuming an inadequate or borderline amount. Ninety-one (75.83%) children consumed an adequate amount of energy derived from fat, whereas 29 (24.17%) children consumed an inadequate or borderline amount of fat calories each day. Finally, 116 (96.67%) children consumed an adequate amount of carbohydrate energy each day, whereas only 4 (3.3%) children consumed an inadequate or borderline amount.

Macronutrient	Adequate		Inadequate/Borderline	
	N	%	N	%
Calories/Energy	96	80	24	20
Protein	118	98.33	2	1.67
Fat	91	75.83	29	24.17
Carbohydrates	116	96.67	4	3.33

Table 2: Macronutrient intake status in children with ASD.

Values were adequate for total caloric intake, but calculated energy contribution from protein, carbohydrates, and fat indicate inadequate relative distribution of intake from fat. Recommended fat intake for children 2 to 3 years of age is 30-35%; recommended fat intake for children 4 and older is 25-35% daily. Percentage of calories from fat was lower than recommended for study subjects.

With regard to micronutrient status, the majority of children consumed an adequate amount of most vitamins and minerals on a daily basis per the 3-day records provided (Table 3). However, there were several notable concerns, and also several exceptions to this:

i) 61 (50.83%) of all children consumed adequate Vitamin A

ii) 2 (1.67%) participants consumed adequate Vitamin D

iii) 32 (26.67%) consumed adequate Vitamin E

iv) 60 (50%) of all participants consumed adequate Vitamin B1

v) 42 (35%) consumed adequate Folate/Folic Acid (Vitamin B9)

Results for other vitamins included 105 (87.50%) children with adequate Vitamin C intake, 77 (64.17%) with adequate B2 intake, 107 (89.17%) with adequate B3 intake, 93 (77.50%) with adequate B6 intake, and 84 (70%) with adequate B12 intake.

Micronutrient	Adequate		Inadequate/Borderline	
	N	%	N	%
Vitamin A RAE	61	50.83	59	49.17
Vitamin C	105	87.5	15	12.5
Vitamin D	2	1.67	118	98.33
Vitamin E	32	26.67	88	73.33
Vitamin B1	60	50	60	50
Vitamin B2	77	64.17	43	35.83
Vitamin B3	107	89.17	13	10.83
Vitamin B6	93	77.5	27	22.5
Folate	42	35	78	65
Vitamin B12	84	70	36	30
Calcium	15	12.5	105	87.5
Iron	101	84.17	19	15.83
Magnesium	70	58.33	50	41.67
Zinc	79	65.83	41	34.17

Table 3: Micronutrient intake status in children with ASD.

Results for minerals included 101 (84.17%) with adequate iron intake, 15 (12.50%) with adequate calcium intake; 70 (58.33%) with adequate magnesium intake, and 79 (65.83%) with adequate zinc intake. For trace mineral micronutrient status (Table 4), 6 (5%) participants consumed adequate iodine; 14 (11.67%) consumed adequate choline; 64 (53.33%) consumed adequate manganese; 25 (20.83%) consumed adequate molybdenum; and 73 (60.83%) consumed adequate selenium intake.

Micronutrient	Adequate		Inadequate/Borderline	
	N	%	N	%
Iodine	6	5	114	95
Choline	14	11.67	106	88.33
Selenium	73	60.83	47	39.17
Manganese	64	53.33	56	46.67
Molybdenum	25	20.83	95	79.17
Potassium	1	0.83	119	99.17

Table 4: Trace mineral micronutrient status in children with ASD.

Finally, we evaluated intake of Omega 3 and Omega 6 fatty acids. Of all study subjects, only 2.5% consumed an adequate amount of Omega 3s, and 5% consumed an adequate amount of Omega 6s (Table 5).

EFA	Adequate		Inadequate/Borderline	
	N	%	N	%
[1]Omega 3	3	2.5	117	97.5
Linolenic (ALA)	4	3.42	113	96.58
[2]Omega 6	6	5	114	95
Linoleic (LA)	8	6.84	109	93.16

Table 5: Essential fatty acid (EFA) intake status in children with ASD. 1Omega 3 and ALA adequate intake is defined as 1.5% of total caloric intake.
2Omega 6 and LA adequate intake is defined as 6.5% of total caloric intake.

The issue of elimination diets has been a concern in dietary nutritional adequacy for children with ASD. The primary elimination diet, which has received attention in recent literature, is that of the gluten- and casein-free (GFCF) diet. This approach eliminates all products containing gluten (protein found in the endosperm of wheat and several other grains) and casein (a family of phosphoproteins found in mammalian milk) from an individual's dietary intake. To speak to this concern, we also chose to evaluate dietary intake also based on a participant's elimination diet status. Sixty children were not on any specified elimination diet. Sixty subjects were following an elimination diet at the time of dietary analysis. Of these, 51 children were following a GFCF diet without any professional guidance, counseling, or support and 9 children were following a GFCF diet with the guidance and support of a variety of practitioners, including knowledgeable physicians, dietitians, and nutritionists. The majority of participants in all 3 groups consumed an adequate amount of total calories, protein, fat, and carbohydrates and results across all 3 groups mirrored results for vitamin and mineral intake with little variation. There were no statistically significant findings (data not shown).

Discussion

The goal in designing and implementing this retrospective review of dietary intake in children with ASD was to evaluate current dietary intake status in this population and further contribute to the research literature in this regard. Our work highlights three main findings. Overall, the majority of children participating in this study consumed an adequate number of total calories as well as protein, fats, and carbohydrates as a percentage of total calorie intake. Micronutrient intake, however, was variable across both fat-soluble and water-soluble vitamins and minerals. Finally, the majority of subjects were deficient in Omega 3 and Omega 6 fatty acids with very few subjects consuming an adequate supply of essential fats on average across the 3 days recorded in the food diary.

Results for macronutrient intake in children with ASD essentially mirror results found in multiple other studies [5,9,10,11,15]. Children met or exceeded recommendations for protein and carbohydrate intake, though based on the excessive protein and carbohydrate intake, the calculated percentage of dietary fat intake is slightly lower than recommended.

Findings regarding adequacy of dietary intake and nutrient intake status in children with ASD have been inconsistent. Vitamin and mineral consumption of study participants was highly variable, with the most significant concerns noted with inadequate fat-soluble vitamin intake for most participants. Intake of two water-soluble vitamins, B1 and folate, was also found to be deficient. Calcium, magnesium, iodine, and potassium intake were insufficient for the majority of subjects. Moore et al report similar findings, with intake below DRIs for calcium, potassium, vitamin D, and vitamin E [10]. Xia et al reported that DRI requirements for Vitamins A, B6, C, folic acid, calcium, and zinc were not met in their study of 111 children between ages 2 and 9 years [9]. Additional studies report inadequate dietary intake for a number of nutrients, including B vitamins, vitamin D, vitamin C, iron, and calcium [5,6,16-23].

Our results indicate that most study participants consumed inadequate amounts of both Omega 3 and Omega 6 essential fatty acids. Most recent nutrition studies have not evaluated dietary intake status of essential fatty acids in children with ASD, though Hyman and colleagues reported decreased linoleic acid (LA) intake [30]. It is important to note that Omega 3 essential fatty acids have been the subject of stand-alone studies for treatment and intervention in children with ASD [24].

Selective eating and food aversion are known concerns for children diagnosed with ASD [5,25-27]. Children with ASD self select foods based on temperature, color, texture, and even packaging of prepared foods [25,28,29]. They tend to prefer sameness and routine, which can result in a severely limited diet [30]. Children with ASD are also known to experience gastrointestinal complaints such as constipation, diarrhea, bloating, and cramping, which could impact the absorption and utilization of nutrients [7,21,31,32]. Together, these factors can influence a child's willingness and ability to consume an adequate number and variety of nutrients to meet their daily needs.

There are several limitations of this study. Firstly, while this study included subjects aged 2-14 years, the number of subjects aged 9-13 were under-represented. Similarly, due to the male preponderance of autism, our subject population only included 12 females. While age and gender were controlled for in the analyses, these variables represent a limitation of this study. Secondly, most families who participated in this study were either referred for care or sought nutritional counseling support, and it is likely that they had concerns about their child's nutrition or feeding behaviors. Thus, their child's dietary patterns may not reflect that of the general population of children with ASD. Finally, 3-Day Food Diaries are self-reported instruments with inherent problems of estimation. To address this, we provided parents with a visual estimation of portion and serving sizes.

In summary, our data indicate that children with ASD are at risk of fat-soluble vitamin (A, D, E), B vitamin (B1 and folate), calcium, magnesium, iodine, and potassium deficiency. Each of these nutrients plays vital roles in growth and development, and could possibly contribute to or exacerbate a child's health and symptoms, which are perceived as a component of their ASD diagnosis. As a result, it is recommended that children with ASD receive a comprehensive nutrition and dietetic evaluation to establish baseline nutritional status and be tracked over time to document health. Such evaluation should include a 3-day food diary analysis to assist in accurately determining dietary intake patterns to assess for potential nutritional deficiencies. Further research is needed to establish and define specific deficiencies as well as therapeutic interventions to address these within this population.

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