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Brief Report

Diet quality in an ethnically diverse sample of children and adolescents with autism spectrum disorder compared with nationally representative data

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ABSTRACT

Background: Children with developmental disabilities are at an increased risk of unhealthy eating habits, which may contribute to compromised growth and development. Children with autism spectrum disorder (ASD) exhibit unique risk factors for unhealthy dietary patterns, including sensory issues and cognitive rigidity at mealtimes.
Objective: This cross-sectional study examined diet quality in a sample of children with ASD in Florida compared to nationally representative National Health and Nutrition Examination Survey (NHANES) 2009–2014/2013-2014 data using the Healthy Eating Index-2015 (HEI-2015).
Methods: A 24-h food record was completed by 41 parents of children with ASD aged 2–17 years, and food and beverage items consumed by each child were reported per standardized 24-h recall protocol. Two models were used to compare mean total and component HEI-2015 scores to NHANES means: (1) comparing means for our full sample to published NHANES means for children aged 2–18 years and (2) a matched model with subjects matched 1:1 by age, gender, race/ethnicity, and parent education level.
Results: HEI component scores were significantly lower (poorer) in children with ASD for whole fruit, total vegetables, dairy, total protein foods, and seafood and plant protein. Whole grains, fatty acids, added sugars, and refined grains scores were higher (better) in our sample. However, total HEI scores and HEI scores for all 13 components were similar among children with ASD and the matched cases from the NHANES data.
Conclusions: There are potential discrepancies in diet quality between children with ASD and general population. Further research with a larger sample size, reporting both total and component HEI scores, is needed.

Introduction

Healthy eating during childhood and adolescence is critical to promote growth and development and to prevent chronic disease.[1] Unhealthy dietary patterns are particularly concerning in children with developmental disabilities, who exhibit an increased risk of obesity and altered eating habits due to disability-related physical or cognitive limitations.[2] Among developmental disabilities, autism spectrum disorder (ASD) may contribute to specific eating challenges, such as sensory issues[3] and cognitive rigidity.[4] Children with ASD exhibit problematic eating behaviors[5] and an increased preference for energy-dense foods.[4,6,7] Such eating behaviors are a risk factor for unhealthy weight gain in children with ASD,[8] who are at a 41.1% increased risk of developing obesity.[9] As ASD is one of the fastest growing developmental disabilities with an estimated prevalence of 1 in 54 children,[10] unhealthy eating behaviors in children with ASD are a growing concern with potential for lifelong impact.

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While nutrition research has shifted from focusing on single nutrients to dietary patterns or diet quality over the past century,[11] diet quality research in youth with ASD is limited. Nutrient intake research has found that children with ASD consume less protein, calcium, phosphorus, selenium, vitamin D, thiamine, riboflavin, vitamin B_{12}, and omega-3 fatty acids and more polyunsaturated fatty acids and vitamin E than typically developing children.[12] Studies examining other dietary aspects focus on nutritional therapies to improve ASD symptoms[13] or variety of foods consumed[14] without assessing diet quality using indices such as the Healthy Eating Index (HEI).[15] Using the HEI, which was created to measure adherence to the Dietary Guidelines for Americans (DGA), research in typically developing children has found diet quality to be inversely associated with obesity.[16] One study found that children with ASD had similar HEI-2005 scores to nationally representative National Health and Nutrition Examination Survey (NHANES) 2003–2004 data, but the sample was limited to children aged 1–6 years, and race/ethnicity and gender were not reported.[17] A study conducted in Spain found that HEI scores in children with ASD aged 6–9 years were not significantly different from typically developing controls.[18] However, these studies only reported the overall HEI scores, while the HEI-2105 consists of several components including nine adequacy components (dietary components to increase) and four moderation components (dietary components to decrease). Reporting individual HEI component scores will improve our understanding of what dietary components contribute to healthy or unhealthy diet quality in children with ASD. Research on dietary patterns in youth with ASD using current, validated indices is necessary to determine possible dietary components to target for intervention.

The purpose of this study was to examine diet quality in a sample of children with ASD aged 2–17 years in Florida using the HEI-2015 and compare with the general population using NHANES data. To our knowledge, this is the first study to report HEI component scores in a wide age range of youth with ASD.

Methods

Participants

For this cross-sectional study, a convenience sample of parents of 41 children with ASD aged 2–17 years was recruited through local schools and clinics for children with ASD and via the University of South Florida listserv from July 2017 until March 2018. Out of 60 parents who contacted the study team, 41 (68.3%) participated. Reported reasons for low response rate were hectic schedules and loss of interest. Inclusion criteria for eligible children were: clinical diagnosis of ASD; aged 0–18 years. Exclusion criterion was a clinical diagnosis requiring treatment or medication that may affect appetite or body weight. No participant was excluded after screening for eligibility. Data on participant demographic characteristics were collected from a mealtime behavior survey that parents were asked to complete online. The study protocol was reviewed and approved by the Institutional Review Board of the University of South Florida. Verbal consent of all participants was obtained. This work was supported by the University of South Florida Research and Innovation Internal Awards Program under Grant No. 0128126.

Food record procedures

A food record for a 24-h period was completed by a parent of each child, and to improve the accuracy of the records, a phone interview was conducted by a registered dietitian or trained research assistant the following day. Each food or beverage item was reported and reviewed as per standardized 24-h recall protocol.[19] Parents confirmed that the reported day represented a typical day of eating for the child. Data collection included time of day, meal or snack, name of dish, ingredients used, and portion of each ingredient according to a validated Food Amounts Booklet,[20] which was referenced by the participant and the researcher during the phone call. The procedure was repeated twice to probe for missing information. Food amounts were converted to standardized units, e.g. ounces or grams.

Diet quality assessment

Data were entered into Nutrition Data System for Research (NDSR) Pilot-Pack software, and energy, macronutrient, micronutrient, food item, and food group intakes were generated to examine diet quality. Diet quality was assessed using the HEI-2015 in SAS version 9.4 (SAS Institute, inc., Cary, NC) with code provided by NDSR[19] for the sample of children with ASD and with code from the National Cancer Institute[20] for NHANES data. The HEI-2015, which is calculated based on density values, or ratios of intake per total energy, includes the following adequacy components: total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood & plant protein, and fatty acids; and the following moderation components: refined grains, sodium, added sugars, and saturated fats. For the total score and all component scores of the HEI-2015, higher scores are more desirable.

Statistical analysis

Means and standard deviations of HEI-2015 scores were compared to general population data from NHANES[21] using (1) all data from our sample of children with ASD aged 2–17 years compared to published means from a nationally representative sample of children aged 2–18 years from NHANES 2009–2014 data,[22] and (2) a matched model compared to NHANES 2013–2014 with subjects matched 1:1 by age, gender, race/ethnicity, and parent education level. The matched model consisted of 33 exact matched pairs that corresponded to all four criteria. The matched pairs differed from the full NHANES 2009–2014 data with regard to gender (76% vs. 51% male). Mann-Whitney U tests were conducted for the matched model. The Benjamini-Hochberg correction method was applied to determine statistical significance adjusting for multiple comparisons.[23,24]

Results

Participant demographics

The mean age for our sample of children with ASD was 8.3 ± 4.0 years, and the sample was 73% male, 39% Non-Hispanic White, 34% Hispanic, 7% Non-Hispanic Black, 2% Asian, and 17% other race/ethnicity. The sample was 37% aged 2–5 years, 39% aged 6–11 years, and 24% aged 12–18 years. Further demographic characteristics for the samples of children with ASD and the control NHANES samples for the unmatched and matched models are depicted in Table 1.

Diet quality

Table 2 compares the mean total and component HEI scores for our sample of children with ASD aged 2–17 years with the published NHANES sample of children aged 2–18 years. The mean total HEI score was 55.9 for our sample of 41 children with ASD aged 2–17 years, which was similar to the NHANES mean for the general

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Table 1
Demographic characteristics for children with ASD aged 2–17 years, a nationally representative sample of children aged 2–18 years from 2009–2014 NHANES data and matched samples of children with ASD and children from 2013–2014 NHANES data.

Variables	Unmatched Model		Matched Model	
	ASD Sample (n = 41)	NHANES Sample % (95% CI)[b]	ASD Sample (n = 33)	NHANES Sample (n = 33)
Age (years)[a]	8.3 ± 4.0[a]	N/A	8.0 ± 3.9	8.4 ± 3.8
Age Group				
2–5 years	15 (37%)	22.7 (21.5, 23.8)	10 (10%)	10 (10%)
6–11 years	16 (39%)	33.7 (32.3, 35.0)	16 (48%)	16 (48%)
12–18 years	10 (24%)	43.7 (42.1, 45.3)	7 (21%)	7 (21%)
Gender				
Boys	30 (73%)	50.8 (49.3, 52.3)	25 (76%)	25 (76%)
Girls	11 (27%)	49.2 (47.7, 50.7)	8 (24%)	8 (24%)
Race/ethnicity				
Non-Hispanic White	16 (39%)	54.7 (49.5, 59.8)	14 (42%)	14 (42%)
Non-Hispanic Black	3 (7%)	13.9 (11.5, 16.3)	3 (7%)	3 (7%)
Hispanic or Latino	14 (34%)	N/A	13 (39%)	13 (39%)
Mexican American	N/A	15.4 (12.0, 18.8)	N/A	N/A
Other Hispanic	N/A	7.3 (5.5, 9.1)	N/A	N/A
Asian	1 (2%)	N/A	1 (3%)	1 (3%)
Other	7 (17%)	8.8 (7.5, 10.1)	2 (6%)	2 (6%)
Parent's highest level of education				
Less than high school	0 (0%)	N/A	0 (0%)	0 (0%)
High school diploma or equivalent	1 (2%)	N/A	1 (3%)	1 (3%)
Some college or Associate's	17 (41%)	N/A	14 (42%)	14 (42%)
College graduate or above	23 (56%)	N/A	18 (55%)	18 (55%)
Poverty-to-income ratio				
Below the threshold (<1)	N/A	24.1 (21.3, 26.9)	N/A	N/A
At or above the threshold (≥1)	N/A	75.9 (73.1, 78.7)	N/A	N/A

SD = Standard deviation.
[a] (Mean ± SD).
[b] Source: (Thomson et al., 2019).

Table 2
Mean differences in HEI-2015 scores between children with ASD and population-level estimates from NHANES 2009–2014 data.

HEI-2015 Score (Maximum)	ASD Sample Mean (95% CI)	NHANES Mean (95% CI)	p-value
Total (100)	55.9 (50.6, 61.2)	54.9 (54.0, 55.8)	0.707
Adequacy			
Total Fruit (5)	3.3 (2.6, 4.0)	3.7 (3.5, 3.8)	0.241
Whole Fruit (5)	3.3 (2.6, 3.9)	4.6 (4.3, 4.9)	<0.001*
Total Vegetables (5)	1.8 (1.2, 2.3)	2.3 (2.2, 2.4)	0.047*
Greens and Beans (5)	1.3 (0.6, 2.0)	1.7 (1.5, 1.8)	0.224
Whole Grains (10)	5.4 (4.0, 6.7)	2.6 (2.4, 2.7)	<0.001*
Dairy (10)	6.2 (4.9, 7.4)	8.9 (8.7, 9.2)	<0.001*
Total Protein Foods (5)	3.8 (3.3, 4.3)	4.6 (4.5, 4.8)	0.003*
Seafood & Plant Protein (5)	1.9 (1.2, 2.7)	3.0 (2.8, 3.3)	0.006*
Fatty Acids (10)	4.7 (3.4, 6.1)	3.1 (2.9, 3.4)	0.018*
Moderation			
Refined Grains (10)	7.1 (6.0, 8.3)	4.7 (4.5, 4.9)	<0.001*
Sodium (10)	4.5 (3.4, 5.7)	4.6 (4.3, 4.8)	0.924
Added Sugars (10)	6.7 (5.6, 7.7)	5.6 (5.4, 5.8)	0.045*
Saturated Fats (10)	5.9 (4.8, 7.0)	5.5 (5.4, 5.7)	0.459

*Significant outcomes based on t-tests; significance levels were adjusted for multiple tests using the Benjamini-Hochberg procedure.
CI = Confidence interval.

population sample of children aged 2–17 years of 54.9 ($p = 0.707$). Five of the 9 adequacy component scores were significantly lower in our sample of children with ASD as compared to NHANES data. Component scores were significantly worse in children with ASD for whole fruit (3.3 vs. 4.6, $p < 0.001$), total vegetables (1.8 vs. 2.3, $p = 0.047$), dairy (6.2 vs. 8.9, $p < 0.001$), total protein foods (3.8 vs. 4.6, $p = 0.003$), and seafood and plant protein (1.9 vs. 3.0, $p = 0.006$).

Children in our sample had higher mean scores for four HEI components. Whole grains (5.4 vs. 2.6, $p < 0.001$) and fatty acids (4.7 vs. 3.1, $p = 0.018$), both adequacy components, were significantly better in our sample of children with ASD, and refined grains (7.1 vs. 4.7, $p < 0.001$) and added sugars (6.7 vs. 5.6, $p = 0.045$), both moderation components, were also better in our sample. There were no significant differences in the other two moderation component scores (sodium and saturated fats) between our sample and NHANES data.

Table 3 compares the mean total and component HEI scores for the samples matched on age, gender, race/ethnicity, and parent education level. The mean total HEI score for the sample of 33 children with ASD was 53.2 ± 18.3, which was similar to the mean for the sample of 33 children from NHANES 2013–2014 data of 50.7 ± 13.4. There were no significant differences in the matched model.

Discussion

The results of this study suggest that overall diet quality of children with ASD may be similar to nationally representative populations, reflected by the total HEI scores. However, comparisons of the sample of children with ASD with published means from NHANES 2009–2014 data indicated that children with ASD may consume fewer whole fruit, total vegetables, dairy, total protein foods, seafood, and plant protein as defined by the HEI-2015. Children with ASD in the sample had better diet quality scores for refined grains, whole grains, added sugars, and fatty acids, which may indicate that parents of children with ASD may be well aware of information on carbohydrates and fatty acids such as omega-3 fatty acids. However, no significant differences were detected for HEI total or component scores in the sample of children with ASD aged 2–17 years and the matched cases on age, gender, race/ethnicity, and parent education level from NHANES 2013–2014 data. Discrepancies in these two analyses may be due to a small number of matched pairs.

Previous studies have also found overall diet quality to be

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Table 3
Mean differences in HEI-2015 scores between children with ASD and a matched sample from NHANES 2013–2014 data.

HEI-2015 Score (Maximum)	ASD sample (n = 33) Mean (SD)	NHANES (n = 33) Mean (SD)	p-value
Total (100)	53.2 (18.3)	50.7 (13.4)	0.369
Adequacy			
Total Fruit (5)	3.0 (2.1)	2.6 (2.2)	0.403
Whole Fruit (5)	3.3 (2.1)	2.3 (2.3)	0.166
Total Vegetables (5)	1.9 (1.8)	2.0 (1.4)	0.500
Greens and Beans (5)	1.2 (2.1)	0.7 (1.5)	0.334
Whole Grains (10)	4.9 (4.4)	3.8 (3.3)	0.353
Dairy (10)	5.6 (3.9)	7.7 (3.0)	0.070
Total Protein Foods (5)	3.7 (1.7)	3.2 (1.9)	0.200
Seafood & Plant Protein (5)	1.6 (2.3)	1.5 (2.1)	0.658
Fatty Acids (10)	4.7 (4.2)	3.7 (3.8)	0.272
Moderation			
Refined Grains (10)	6.5 (4.0)	6.4 (3.3)	0.628
Sodium (10)	4.5 (3.4)	5.5 (3.6)	0.295
Added Sugars (10)	6.4 (3.5)	5.6 (3.4)	0.306
Saturated Fats (10)	5.9 (3.5)	5.7 (3.9)	0.709

SD = Standard deviation.

similar between children with ASD and comparison groups but did not report component scores.[17,18] Without investigating the detailed component scores that the HEI provides, inadequate or excess intake of specific food groups may be overlooked. Our findings on the component scores in the unmatched analysis indicate that higher scores for moderation food components in children with ASD contributed to an increased overall HEI score, while several adequacy component scores in children with ASD were still lower than general population data. As there were no significant differences detected in the matched analysis, future research on factors associated with diet quality in children with ASD is needed.

Two previous studies used overall HEI scores to examine diet quality in young children with ASD (aged 1–6 years[17] and aged 6–9 years[18]) and reported HEI scores between 61.9 and 65.3 for children with ASD and between 66.2 and 68.1 for control groups. Further research is needed on diet quality in adolescents with ASD and in all youth with ASD that include component scores to analyze whether diet quality scores in children with ASD are consistent with findings on nutrient and food group intake. For example, previous studies suggest a low intake of fruit and vegetables in children with ASD[25] and inadequate intakes of micronutrients such as B-vitamins.[12] Our findings from this study are consistent with our preliminary nutrient intake analysis of the same sample, which indicated no difference in most nutrients.[26]

Further research on diet quality and age, gender, race/ethnicity, and socioeconomic factors is needed to be able to appropriately tailor interventions that aim to promote healthy growth and development in this population. Diet quality has not been adequately addressed for children with ASD because previous studies mainly focused on nutrient deficiencies in this population. However, considering the high prevalence of obesity and risks for chronic diseases such as type 2 diabetes among youth with ASD,[9,27] further research on diet quality and how it affects the health and development of children with ASD is needed. One previous study showed that the overall HEI score among children with ASD worsens with increased problematic feeding behaviors[28] but did not report which HEI components contribute to the difference in overall scores. As research in this area is limited, future studies should investigate this relationship and how to improve diet quality while addressing specific feeding challenges in children with ASD.

Shortcomings of the study include convenience sampling method, small sample size, and potential self-report bias. Therefore, our findings cannot be generalized to all children with ASD. Nevertheless, this study adds critical data to the literature by using the HEI-2015 to analyze diet quality in an ethnically diverse sample of children with ASD. Our sample reflects the estimated male:female ASD diagnosis ratio of 3:1[29] and the estimated 1.2 White:Hispanic prevalence ratio,[10] while many studies fail to report race/ethnicity data in their analysis of dietary intake in children with ASD.

Due to the fact that significant findings were detected in the unmatched analysis but not the matched analysis, a large study with diverse age, gender, race/ethnicity, and socioeconomic groups is warranted. Although there were several statistically significant differences in the unmatched analysis, there were overlapping distributions between groups for total vegetable, fatty acid, and added sugar component scores, lending to weaker support for between-group differences. As children with ASD have unique risk factors for nutrient deficiencies and obesity in addition to physical limitations that other children with disabilities may experience, knowledge about diet quality has the potential to impact multiple pressing public health concerns for this population.

Declaration of competing interest

All authors reported no conflicts of interest to disclose. Part of this study was presented as a conference abstract at the annual meeting of Society Nutrition Education and Behavior in July 2018.

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