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Nutrient adequacy, dietary patterns and diet quality among children with and without intellectual disabilities

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Abstract

Background—Children with intellectual disabilities (ID) frequently have feeding problems, but there has been limited research on nutrient intake, dietary patterns and diet quality in this population.

Method—Nutrient intakes, dietary patterns and the Healthy Eating Index were compared between 48 children with ID and 55 typically developing (TD) children aged 3–8 years who participated in the Children's Mealtime Study. Three-day food records that included two weekdays and one weekend day were used to assess dietary intake. Food intake was entered into the Nutrition Data System for Research for analysis of nutrient intake, dietary patterns and diet quality. Height and

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No conflicts of interest have been declared.

weight were measured to determine body mass index (BMI). The relation of dietary patterns to weight status was also assessed.

Results—Typically developing children and children with ID met the Estimated Average Requirement/Adequate Intake (EAR/AI) for most nutrients. However, a substantial number of children in both groups did not meet the EAR for vitamins E and D and calcium and the AI for vitamin K. Only one TD child met the AI for potassium. A small percentage of children in both groups did not meet the EAR for vitamin A and vitamin C, and in the ID group, a small percentage did not meet the EAR for vitamin B_{12}. Children in the ID group consumed, on average, fewer servings of vegetables than TD children (0.5 vs. 1.2, $P < 0.001$), but there was no significant difference in servings of fruit (0.8 vs. 1.1, respectively), fruit juice (less than a half serving in both groups), sugar-sweetened beverages (less than a half serving in both groups) or snacks (1.1 vs. 1.4, respectively) after adjusting for BMI *z*-score, parental education and race. We found a significant correlation between snack intake and BMI *z*-score among children with ID but not among TD children ($r = 0.48$, $P < 0.0001$ vs. $r = 0.19$, $P = 0.16$, respectively). The Healthy Eating Index indicated, on average, poor overall diet quality in both groups (58.2 in the ID group and 59.1 in the TD group).

Conclusions—This study suggests that the diets of children with ID, as in TD children, need improvement. Targeting healthy eating in children with ID would improve diet quality and overall health.

Keywords

children; dietary patterns; Healthy Eating Index; intellectual disability; nutrient adequacy

Introduction

Children with intellectual disabilities (ID) have limitations in both cognitive functioning and adaptive behaviour (American Association on Intellectual and Developmental Disabilities 2020) as well as behavioural, oral motor and sensory challenges, all of which may impact activities of daily living and behaviours associated with overall health and well-being. In a study of children referred to an interdisciplinary feeding treatment team, Fields et al. (2003) found that food selectivity was most common among children with autism spectrum disorder (ASD), and oral motor problems and food selectivity were common among children with Down syndrome (DS). In a recent review of children with DS, Nordstrøm et al. (2020) reported that feeding and swallowing problems are common in children with DS.

Although it has been well documented that children with developmental disabilities such as ASD are likely to have feeding problems (Sharp et al. 2013) and have an elevated risk for inadequate nutrient intake (Bandini et al. 2010; Zimmer et al. 2011), only a few studies have examined dietary intake in children with ID. Most of this research has focused on children with DS but has been limited by very small sample sizes (Luke et al. 1996), the inclusion of very young children only (Hopman et al. 1998) or analyses of only a single nutrient (Lima et al. 2010). Of the two studies in children with DS that examined overall nutrient intake (Grammatikopoulou et al. 2008; Magenis et al. 2018), both found that a substantial number of children did not meet the dietary reference intakes for several nutrients. Although some studies have documented that children with ASD have lower intakes of fruits and vegetables and a higher preference for high-calorie/low nutrient-dense foods compared with typically developing (TD) peers (Schreck et al. 2004; Evans et al. 2012; Graf-Myles et al. 2013), corresponding studies of children with ID are lacking.

Feeding problems and diets of limited variety in children can lead to nutritional inadequacy and poor diet quality. For example, studies in children with ASD (Bandini et al. 2010; Hyman et al. 2012; Graf-Myles et al. 2013; Marí-Bauset et al. 2017) and ID (Magenis et al. 2018) have reported inadequate intakes of several nutrients. Inadequate nutrient intake can impact on growth, development and overall health, and diets limited in fruits and vegetables and high in saturated fats and added sugars may increase the risk for obesity (He et al. 2004) and other chronic diseases later in life (Hung et al. 2004).

In a previous report, we reported on the relationship of nutrient inadequacy to food selectivity in children with ID (Bandini et al. 2019). In the present study, we have extended this work by investigating nutrient adequacy, dietary patterns and diet quality in children with ID compared with TD children, as well as examining whether weight status is related to dietary patterns. In addition, we also determine whether nutrient intake, dietary patterns and diet quality differ among children with ID with and without co-occurrence of probable ASD.

Methods

Participants in the present study were 3–8 years of age (mean age = 6 years) and enrolled in the Children's Mealtime Study (Bandini et al. 2019), and their parents completed a 3-day food record. Participants were recruited through parent support networks, schools, disability-related organisations, list-servs, print and online advertising, and hospital-based clinics. Children with ID included those with DS, other genetic syndromes, ID of unexplained aetiology and children with ID who also had probable ASD. The children were healthy and had no history of chronic illness or physical disabilities. Parents who inquired about the study were screened over the phone to determine if their child was eligible. Parents of both children who had an ID and those children who were TD were asked a series of questions, including items regarding early intervention and language and motor development, to ensure that TD children did not have any developmental delays.

For those children who were determined likely to have ID based on screening questions, we administered the Differential Ability Scales (Elliott 1990) to the children and the Vineland Adaptive Behavior Scales (Sparrow et al. 2005) to the parents to confirm the presence of an ID. The Autism Spectrum Rating Scale (Goldstein & Naglieri 2010) was completed by parents of children with ID to determine the probability of the child having ASD, as previously described (Bandini et al. 2019). Inclusion criterion for the study was a score on the Differential Ability Scales and Vineland Adaptive Behavior Scales ≤75. The study received approval from the University of Massachusetts Medical School Institutional Review Board. Parents or guardians provided written informed consent. TD children over the age of 6 provided assent. Both parent and child received a gift card to a selected community and/or online vendor as a stipend for their participation.

Participant visits were conducted at University of Massachusetts Medical School sites in Waltham, Charlestown and Worcester, Massachusetts, and in community locations including schools, libraries and participants' homes.

Parents completed a demographic/medical questionnaire and diet history questionnaire that included questions about whether their child was following a special diet, as previously described (Bandini et al. 2019). They were instructed by a registered dietitian nutritionist (RDN) or nutrition graduate student on keeping a 3-day food record, which included recording all food the child ate or drank (except water) during two consecutive weekdays and one weekend day. Occasionally, if parents were unable to record on a specific day, adjustments were made. Parents were trained in how to keep a food record using food models and packaged foods. They were given measuring cups and spoons and a ruler to take home to estimate portion size. When the diaries were returned, an RDN reviewed the record and contacted parents for any needed clarifications. For younger school-age children in both groups, parents asked teachers to report uneaten portions of snacks or lunch. For older school-age children, parents recorded what they sent to school and reviewed with their children what they had eaten that day. If the child had purchased lunch at school, parents reviewed what their child consumed at school and added this information to the food record. The study was conducted throughout the year.

Children were weighed and measured in light clothing on a Seca scale and stadiometer. Body mass index (BMI) was calculated and referenced against the sex-specific and age-specific Centers for Disease Control and Prevention childhood growth reference (Ogden et al. 2002) to determine BMI z-score and classify obesity as recommended (Centers for Disease Control and Prevention 2018).

Dietary analyses

Three-day food records were entered into the Nutrition Data System for Research (NDSR) (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN) and analysed for nutrient composition, dietary patterns and diet quality.

Nutrient intake

For each participant, the 3 days of recording were averaged for each nutrient. We defined nutritional inadequacy relative to the Estimated Average Requirement (EAR) for the specific sex and life stage. For vitamin K and potassium, for which an EAR is not established, we used the Adequate Intake (AI) [Institute of Medicine (IOM) 2005, 2006, 2011].

Dietary patterns

We compared the intake of vegetables, fruits, fruit juice, sugar-sweetened beverages (SSBs) and snack foods between children with ID and TD children. For these analyses, vegetables included dark green, dark yellow, fried vegetables, other vegetables, white potatoes, other starchy vegetables, legumes, tomatoes and avocados. French-fried potatoes were not included. Fruits included citrus and non-citrus fruits and fruit juice (both citrus and non-citrus). SSBs included sweetened soft drinks, sweetened fruit drinks, sweetened coffee, sweetened coffee substitutes, sweetened water, sweetened tea and sweetened meal replacement beverages. Snacks included cakes, cookies, pies, pastries, Danish, doughnuts, cobblers, snack bars, snack chips, popcorn, frozen dairy desserts, puddings, other dairy desserts, miscellaneous desserts, frosting and candy.

Diet quality

We used the Healthy Eating Index (HEI) as a measure of diet quality that reflects adherence to the U.S. Departments of Health and Human Services and Agriculture Dietary Guidelines (U.S. Department of Agriculture & U.S. Department of Health and Human Services 2015). The HEI was updated in 2005 (Guenther et al. 2008), in 2010 (Guenther et al. 2013) and again in 2015 (Krebs-Smith et al. 2018), following publication of the Dietary Guidelines for Americans in 2005, 2010 and 2015, respectively (U.S. Department of Agriculture & U.S. Department of Health and Human Services 2005, 2010, 2015). The HEI score is based on two characteristics of the diet: adequacy and moderation. Adequacy is based on intake of total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and fatty acids and the extent of adherence to the Dietary Guidelines. Moderation is based on limited intakes of refined grains, sodium, added sugars and saturated fat as defined by the Dietary Guidelines. Scores range from 0 to 100, with a higher score indicating higher diet quality. The HEI scores were calculated using programmes provided by NDSR for the HEI-2015 (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN) to correspond to the data collection period, which began in July 2013 and ended in August 2016. The HEI scoring algorithm was applied to each participant based on their average intake from the 3-day food records. These individual scores were then used to provide mean HEI total and component scores.

Statistical analysis

Baseline characteristics between children with ID and TD children were compared using chi-squared tests for categorical variables and two-sample *t*-tests for continuous variables. Analysis of covariance was used to assess differences between children with ID and TD children in 3-day average nutrient intake, food group servings, total average HEI and average HEI components. Results are presented in terms of adjusted means (standard error) and mean difference (with 95% confidence intervals). Unless otherwise indicated, all nutrient, food and HEI analyses were adjusted for BMI *z*-score, parental education (college and no college) and race (White and non-White). Prior to analysis, distributions of outcome data were examined for normality; when needed, natural log transformations were applied with results back-transformed to their original scale for presentation, which yielded geometric means. Unadjusted nutrient adequacy for each group was compared using chi-squared tests. Crude Spearman correlation coefficients were used to assess the relationship of weight status (BMI *z*-score) to food group servings. In further analyses, analysis of covariance was used to analyse 3-day average nutrient intake, food group servings, total average HEI and average HEI components across TD children, children with ID only and children with ID plus probable ASD with the aforementioned covariates. We assessed the significance of linear trends across the three categories of disability status using linear regression with the same covariates. Results that yielded P-values <0.05 were deemed to be statistically significant. All analyses were conducted in SAS version 9.4 (SAS Institute, Cary, NC).

Results

Participant characteristics

Characteristics of the study participants are presented in Table 1. There were no significant differences in mean age, sex, parental education, race/ethnicity or casein-free diets between children with ID and TD children. The average (standard deviation) scores on the Differential Abilities Scale (General Conceptual Ability score) and the Vineland Adaptive Behavioral Composite Standard Score for children with ID were 49.5 (13.4) and 65.2 (7.9), respectively. Children with ID followed gluten-free and lactose-free diets more frequently than did TD children (10% vs. 0%, $P = 0.02$ for both gluten-free and lactose-free diets). In both groups, more than half of the participants were male. With regard to weight status, there was a significant difference in BMI percentile between the two groups, with the children with ID having a higher mean BMI percentile compared with TD children (80.7 vs. 60.2, $P < 0.001$). Thirty-seven per cent of children with ID met criteria for obesity vs. 13% of TD children ($P = 0.005$). Two of the children in the TD group and none of the children in the ID group met criteria for underweight. BMI was unavailable for two children for whom weight or height could not be obtained.

Nutrient intake

Table 2 summarises and compares the mean intake of energy and macronutrients between the two groups of children. Intakes of calories, fibre, percentages of fat and carbohydrates in relation to total caloric intake were similar between children with and without ID. Both groups met the EAR for protein. However, children with ID reported, on average, lower total protein intake than TD children (53.1 vs. 60.2 g, $P < 0.04$; ID vs. TD, respectively), but these differences were not statistically significant when protein was examined as a percentage of total caloric intake (14.6%kcal vs. 15.1%kcal, $P = 0.58$; ID vs. TD, respectively). Added sugar intake showed a marginal mean difference between the two groups, with ID children reporting lower added sugar intake than TD (36.0 vs. 46.3 g, $P = 0.05$).

Micronutrient intakes for the two groups of children are presented in Table 3. Eighteen vitamins and minerals were analysed for both level of intake and nutritional adequacy, as defined by the EAR or AI. In the adjusted analysis, we found statistically significant differences in intakes of niacin, folate and vitamins B_{12}, A and K, with ID children reporting, on average, lower intakes than TD children. Children in both groups met the EAR for niacin, thiamin, folate, riboflavin, vitamin B_6, phosphorus, magnesium and iron. Only one TD child did not meet the EAR for zinc, and only one ID child did not meet the EAR for sodium. A small percentage of children in both groups (4% in the TD group and 8% in the ID group) did not meet the EAR for vitamin A, and 7% in the TD group and 8% in the ID group did not meet the EAR for vitamin C. A small percentage of children with ID (6%) did not meet the EAR for vitamin B_{12}. Of note, a substantial proportion of children in both groups did not meet the EARs for vitamins E and D and calcium and the AI for vitamin K. Only one TD child met the AI for potassium. Half of the children in both groups had inadequate intakes of four or more nutrients.

We conducted further analyses that assessed linear trends in nutrient intake across TD children, children with ID only and children with both ID and probable ASD (Tables 4,5). For macronutrients, we observed statistically significant linear trends in mean protein intake (TD = 60.5, ID only = 60.4 and ID/ASD = 49.1, *P*-trend = 0.004) and added sugar intake (TD = 46.6, ID only = 43.6 and ID/ASD = 32.0, *P*-trend = 0.013). Children with both ID and probable ASD had the lowest intake. However, when protein was examined as per cent of calories, the findings were not significant (TD = 15.1, ID only = 16.1 and ID/ASD = 13.7, *P*-trend = 0.143) (Table 4). For those micronutrients for which a substantial number of participants did not meet the EAR/AI intake, vitamin D and K showed marginally significant linear trends with highest mean intake reported in TD children and lowest in children with both ID and probable ASD (vitamin D: TD = 6.0, ID only = 4.9 and ID/ASD = 4.3, *P*-trend = 0.048; vitamin K: TD = 60.7, ID only = 49.0 and ID/ASD = 40.4, *P*-trend = 0.037) (Table 5).

Dietary patterns

Differences in dietary patterns between children with ID and TD children were also evaluated. Children with ID had a significantly lower intake of vegetables compared with TD children. Children with ID reported an average intake of 0.54 servings of vegetables per day in comparison with 1.23 daily servings in TD children ($P < 0.001$). Relative to fruit intake, children with ID consumed an average of 0.75 servings of fruit per day in comparison with 1.11 daily servings consumed by TD children ($P = 0.12$). Fruit juice and SSB intakes were similar between children with and without ID. Both groups reported a mean intake of SSBs and 100% fruit juice to be less than a half a serving per day. Snack intake was, on average, 1.08 servings per day in the ID group and 1.41 servings in the TD group. ($P = 0.19$) (Table 6). Further analyses assessing linear trends across disability status showed an inverse relationship in mean vegetable intake across the groups (TD = 1.24, ID only = 0.86 and ID/ASD = 0.40, *P*-trend <0.0001) (Table 7).

Tomatoes, carrots, potatoes, beans and corn were the five most commonly consumed vegetables. Apples, bananas, grapes, strawberries and oranges comprised the top 5 most common fruit choices for both the ID and TD groups.

Dietary patterns and weight status

There were no significant associations, based on Spearman rank correlation coefficients, between children's intakes of fruit and vegetables with BMI *z*-score in either group (vegetables: TD $r = 0.20$ and ID $r = 0.27$; fruit: TD $r = 0.04$ and ID $r = -0.03$). There were also no significant relationships with BMI *z*-score in either group with intakes of SSBs and added sugars (SSB: TD $r = -0.08$ and ID $r = 0.25$; added sugar: TD $r = -0.03$ and ID $r = 0.27$). However, the Spearman rank correlation of snack intake with BMI *z*-score was moderate and significant in the ID group (ID $r = 0.48$, $P < 0.001$; TD $r = -0.19$, $P = 0.16$).

Healthy eating index scores

Analyses of HEI scores are presented in Tables 8 and 9. The overall mean HEI score between children with TD and ID children was not statistically different (59.1 in TD vs. 58.2 in ID, $P = 0.76$). Regarding individual food categories, there were significant mean differences found between TD children and children with ID in scores for intake of total vegetables (2.4 vs. 1.2, $P < 0.001$, TD and ID, respectively) and greens and beans (1.9 vs. 1.0, $P = 0.03$), dairy (8.6 vs. 7.4, $P = 0.04$), seafood and plant proteins (2.8 vs. 1.9, $P = 0.05$), and whole fruits (3.8 vs. 3.1, $P = 0.05$), with children with ID having lower scores.

Further analyses assessing linear trends across disability status were performed by disaggregating children with ID from those with ID and probable ASD. There were no significant linear trends with regard to total HEI scores (TD = 58.9, ID only = 54.5 and ID/ASD = 60.4, P-trend = 0.723). However, there were significant mean differences identified for intake of total vegetables (TD = 2.4, ID only = 1.6 and ID/ASD = 1.1, P-trend ≤ 0.001), greens and beans (TD = 1.9, ID only = 1.4 and ID/ASD = 0.8, P-trend = 0.021), and total protein (TD = 4.0, ID only = 4.0 and ID/ASD = 3.3, P-trend = 0.033) with those children with both ID and probable ASD having the lowest scores. On average, children with both ID and probable ASD group had higher scores on refined grain intake (TD = 4.5, ID only = 4.5 and ID/ASD = 6.3, P-trend = 0.030) and fatty acid intake (TD = 3.2, ID only = 3.0 and ID/ASD = 5.1, P-trend = 0.037).

Discussion

We sought to examine nutrient intake, dietary patterns and HEI scores of children with ID in comparison with their TD peers. In spite of the fact that children with ID had lower intakes of several micronutrients, most met the EARs/AIs. Analysis of the children's dietary patterns revealed lower intakes of fruit and vegetables for ID children compared with TD children. Relative to the HEI, a measure of diet quality, several component scores for children with ID were lower than for TD children (i.e. total vegetables, green beans, dairy, fruit and seafood/plant proteins). However, there was no statistically significant difference in the overall HEI score between the two groups and it was poor in both groups.

Although a substantial amount of nutrition-related research exists on children with ASD, nutrient intake in children with ID has not been widely studied. The literature suggests that sensory sensitivity is often seen in children with ASD and may explain their preferences for textures, colours and flavours (Cermak et al. 2010; Chistol et al. 2018), as well as their propensity for food selectivity (Bandini et al. 2010). These factors may also be associated with the eating patterns seen in children with ID (Engel-Yeger et al. 2011, 2015). Given the dearth of research in this area for children with ID, additional research is needed to determine whether these children are at elevated risk for deficiency of certain nutrients.

There were several key findings in our study about the dietary intakes among children with ID, some of which were consistent with previous studies in children with ASD and DS. First, a substantial proportion of children with ID did not meet the EAR for vitamin D. This finding is consistent with studies of children with ASD (Zimmer et al. 2011; Hyman et al. 2012; Graf-Myles et al. 2013; Marí-Bauset et al. 2017) and in children with DS (Magenis et al. 2018), which also used the EAR as a standard or reference. Second, calcium intake was below the EAR in a large portion of children with ID, similar to previous findings reported in children with ASD (Lockner et al. 2008; Zimmer et al. 2011; Hyman et al. 2012; Bicer & Alsaffar 2013; Marí-Bauset et al. 2017) and in children with DS (Magenis et al. 2018).

In our previous analysis, a small percentage of children with ID had inadequate intakes of vitamins A, C, E and K, which is likely due to the limited intake of fruits and vegetables, and may be a reflection of food selectivity (Bandini et al. 2019).

Our findings suggest that potassium and vitamin D are lacking in the diets of both children with ID and TD children. All but one child in our study did not meet the AI for potassium, which may reflect the low intake of fruits and vegetables in the children's diets. However, it is important to note that this finding may also be due to the recommendations at the time of this study (2013–2016), when the AI for potassium was much higher than the current (2019) recommendations (IOM 2019). The low intake of vitamin D we observed in children who are TD and in children with ID is similar to findings reported for children studied in the US National Health and Nutrition Examination Survey 2009–2012 (Newman et al. 2019).

Lastly, dietary fibre intake in both groups was below the dietary reference intake (IOM 2005). Low levels of fibre have been documented in children with ASD (Lockner et al. 2008; Herndon et al. 2009; Hyman et al. 2012; Bicer & Alsaffar 2013; Graf-Myles et al. 2013; Marí-Bauset et al. 2017) and in children with DS (Luke et al. 1996; Magenis et al. 2018).

The low intake of vegetables and fruits we observed in the children's diets across both groups may contribute to the risk for chronic disease later in life if these patterns continue. The lower intake of vegetables in the ID group may be related to sensory sensitivity commonly reported in children with ASD and developmental disabilities (Fields et al. 2003; Cermak et al. 2010). Given that dietary habits are established early in life (Velde et al. 2007), there is a great need for interventions to increase fruits and vegetables in children. Our observation of a significant positive association between snack intake and BMI percentile, as well as positive though non-significant correlations with SSBs and added sugars in the ID group, support targeting the reduction of these foods to prevent excess weight gain. However, these findings are cross-sectional; prospective studies to examine dietary patterns in relation to later weight status in this population are needed.

Overall, the mean HEI scores we observed earned a grade of 'F' (scores of 0 to 59) for the ID children (score of 58.2) and close to an 'F' for TD children (score of 59.1) (Krebs-Smith et al. 2018). Only 4.2% of children with ID and 10.9% of TD children had a mean HEI score above 80. Previous research has also documented low HEI in children with ASD (Graf-Myles et al. 2013; Johnson et al. 2014; Marí-Bauset et al. 2017).

Our findings should be considered in the context of some limitations in our approach. We recruited convenience samples of children with and without ID, so the samples are not representative of the general population. Furthermore, the proportion of children with DS or ASD in the study was much higher than in the general population of children with ID. Our dietary data were obtained from a 3-day food record, which has well-known limitations arising from issues of incomplete reporting of foods, portion sizes and limitations in the NDSR food database. However, we provided detailed instruction to parents on how to complete a 3-day food record, and an RDN reviewed each completed record when it was returned and contacted parents if they needed clarification. We also relied on the cooperation of teachers to return uneaten foods for younger children. These efforts likely helped reduce inaccuracies or incomplete reporting, but some limitations in food record reporting remain. These limitations all contribute to measurement error, which we would expect to be similar in the two groups and would tend to make it more difficult to see relationships if they exist. In addition, we did not account for dietary supplements in our analysis of nutrition adequacy.

In our subgroup analyses where we did a three-group comparison (ID only, ID + ASD and TD), our characterisation of the presence of ASD relied on the Autism Spectrum Rating Scale, which yields a finding of 'probable ASD', rather than a confirmatory diagnosis of ASD. Thus, some misclassification in group assignment is possible. To the extent this was true, it would make identification of any true differences more difficult to observe. Finally, our samples were only moderate in size, so the failure to discern some group differences may reflect limitations of statistical power.

There were also several strengths of this study. We examined three complementary measures of dietary intake, generating a comprehensive profile of the participants' diets. Our subgroup examination of differences in diets between children with ID with and without probable ASD constitutes one of the first reports on the dietary differences between these two groups. Finally, we were able to recruit a diverse sample, with good representation of non-White participants.

Overall, the findings from our analysis on nutrient intake suggest that although the children in both groups are meeting the recommendations for most nutrients, a substantial number of children in both groups did not meet the EAR/AI for calcium, vitamins D, E and K, and potassium. Additionally, a substantial proportion of children had inadequate intakes of four or more nutrients. The diets of both groups of children were lacking in fruits and vegetables, and the mean overall HEI was poor in both groups. These three indices together strongly suggest that efforts to improve the diets of children in general are warranted.

Further research in children with ID is needed to confirm our findings. Additionally, prospective studies that follow children with ID from early childhood to school age would elucidate the extent to which early dietary patterns persist and whether they are related to later weight status. Given the sensory, oral motor and behavioural challenges often seen in children with ID, it is likely that attention to and development of tailored interventions to improve the diet quality in this population will be necessary.

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Data Availability Statement

Research data are not shared.

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Table 1

Participant characteristics

	TD (n = 55)	ID (n = 48)	*P*-value[†]
Age, mean (SD)	5.9 (1.7)	6.0 (1.8)	0.79
Male, n (%)	32 (58%)	32 (67%)	0.38
Race, White, n (%)	21 (38%)	26 (54%)	0.10
Parent graduated college, n (%)	41 (75%)	29 (60%)	0.13
Diagnosis, n (%)			
Down syndrome	—	26 (54%)	—
Probable autism spectrum disorder[‡]	—	30 (63%)	—
Other	—	5 (10%)	—
Vineland Adaptive Behavior Composite Standard Score, mean (SD)	—	65.2 (7.9)	
DAS General Conceptual Ability, mean (SD)	—	49.5 (13.4)	
Special diets, n (%)			
Gluten-free	0	5 (10%)[§]	0.02
Lactose-free	0	5 (10%)	0.02
Casein-free	1 (2%)	3 (6%)	0.33
BMI z-score, mean (SD)	0.4 (1.0)	1.2 (1.0)[¶]	<0.001
BMI percentile, mean (SD)	60.2 (28.1)	80.7 (21.5)[¶]	<0.001
Overweight, n (%)	5 (9%)	6 (13%)[¶]	0.52
Obese, n (%)	7 (13%)	17 (37%)[¶]	0.004

[†] *t*-test for continuous variables and chi-squared test for categorical variables.

[‡] As assessed by the ASRS.

[§] n = 47.

[¶] n = 46.

BMI, body mass index; DAS, Differential Ability Scales; ID, intellectual disability; SD, standard deviation; TD, typically developing.

Table 2

Energy and macronutrient intakes by group (TD and ID)[†]

Nutrient	TD (n = 55) Adjusted mean (SE)	ID (n = 48) Adjusted mean (SE)	Adjusted mean difference (95% CI)[‡]	*P*-value
%kcal from fat	30.6 (0.9)	30.3 (0.9)	−0.3 (−2.8, 2.2)	0.83
%kcal from carbohydrate	54.3 (0.9)	55.1 (1.0)	0.8 (−2.0, 3.5)	0.58
%kcal from protein	15.1 (0.5)	14.6 (0.5)	−0.5 (−2.0, 1.1)	0.54
	Adjusted geometric mean (SE)	**Adjusted geometric mean (SE)**	**Adjusted relative mean difference (%) (95% CI)[‡]**	
Energy (kcal)	1625.5 (1.0)	1522.8 (1.0)	−6.3 (−15.3, 3.6)	0.20
Protein (g)	60.2 (1.0)	53.1 (1.0)	−11.8 (−22.0, −0.4)	0.04
Fibre (g)	14.5 (1.1)	13.1 (1.1)	−9.8 (−23.8, 6.8)	0.23
Added sugars (g)	46.3 (1.1)	36.0 (1.1)	−22.3 (−39.9, 0.4)	0.05

[†] All analyses adjusted for BMI *z*-score, parent education (college and no college) and race (White and non-White).

[‡] Mean difference is presented as difference (ID – TD) for arithmetic means and per cent change from TD for geometric means.

BMI, body mass index; CI, confidence interval; ID, intellectual disability; SE, standard error; TD, typically developing.

Table 3

Micronutrient intakes by group (TD and ID)

Nutrient	TD (n = 55) Adjusted mean (SE)[†]	ID (n = 48) Adjusted mean (SE)[†]	Adjusted mean difference (95% CI)[†,‡]	*P*-value[†]	TD % meeting[§] EAR/AI	ID % meeting[§] EAR/AI	*P*-value[§] (chi-squared)
Niacin (mg niacin equivalents)	32.1 (1.3)	27.3 (1.4)	−4.8 (−8.7, −0.9)	0.02	100%	100%	
Vitamin B_{12} (μg)	4.9 (0.3)	3.9 (0.3)	−0.9 (−1.7, −0.2)	0.02	100%	94%	0.10
Calcium (mg)	988.0 (56.3)	892.6 (59.1)	−95.4 (−259.6, 68.9)	0.25	62%	65%	0.77
Phosphorus (mg)	1112.4 (44.8)	1008.5 (47.0)	−103.9 (−234.6, 26.8)	0.12	100%	100%	
	TD Adjusted geometric mean (SE)[†]	**ID Adjusted geometric mean (SE)[†]**	**Adjusted relative mean difference (%) (95% CI)[†,‡]**	***P*-value[†]**	**TD % meeting[§] EAR/AI**	**ID % meeting[§] EAR/AI**	***P*-value[§] (chi-squared)**
Vitamin A (μg RAE)	644.9 (1.1)	518.4 (1.1)	−19.6 (−35.6, 0.3)	0.05	96%	92%	0.41
Vitamin D (μg)	6.0 (1.1)	4.5 (1.1)	−23.7 (−42.3, 1.0)	0.06	18%	10%	0.27
Vitamin E (total α-tocopherol, mg)	5.6 (1.1)	6.1 (1.1)	9.9 (−11.6, 36.6)	0.39	35%	50%	0.11
Vitamin K (μg)	60.5 (1.1)	43.4 (1.1)	−28.2 (−48.7, 0.7)	0.05	55%	40%	0.13
Vitamin C (mg)	61.8 (1.1)	55.9 (1.1)	−9.4 (−35.6, 27.4)	0.57	93%	92%	0.99
Thiamin (mg)	1.5 (1.1)	1.4 (1.1)	−12.0 (−24.2, 2.3)	0.10	100%	100%	
Folate (μg DFE)	493.7 (1.1)	386.7 (1.1)	−21.7 (−35.1, −5.4)	0.01	100%	100%	
Riboflavin (mg)	1.9 (1.1)	1.7 (1.1)	−13.7 (−26.3, 1.2)	0.07	100%	100%	
Vitamin B_6 (mg)	1.5 (1.1)	1.4 (1.1)	−12.2 (−25.6, 3.5)	0.12	100%	100%	
Magnesium (mg)	215.5 (1.0)	209.2 (1.0)	−2.9 (−15.0, 10.8)	0.66	100%	100%	
Iron (mg)	12.5 (1.1)	10.8 (1.1)	−14.1 (−27.5, 1.9)	0.08	100%	100%	
Zinc (mg)	8.6 (1.1)	7.7 (1.1)	−9.9 (−22.1, 4.3)	0.16	98%	100%	0.99
Sodium (mg)[¶]	2381.4 (1.1)	2050.3 (1.1)	−13.9 (−25.4, −0.7)	0.04	100%	98%	0.47
Potassium (mg)	1936.8 (1.0)	1868.2 (1.0)	−3.5 (−15.3, 9.8)	0.58	2%	0%	0.99

[†] Analyses adjusted for BMI *z*-score, parent education (college and no college) and race (White and non-White).

[‡] Mean difference is presented as difference (ID – TD) for arithmetic means and per cent change from TD for geometric means.

[§] Unadjusted analyses.

[¶] Does not include table salt.

AI, Adequate Intake; BMI, body mass index; CI, confidence interval; DFE, dietary folate equivalents; EAR, Estimated Average Requirement; ID, intellectual disability; RAE, retinol activity equivalents; SE, standard error; TD, typically developing.

Table 4

Energy and macronutrients by group (TD, ID only and ID/ASD)[†]

Nutrient	TD (n = 55) Adjusted mean (SE)	ID only (n = 18) Adjusted mean (SE)	ID/ASD (n = 30) Adjusted mean (SE)	*P*-value Test for trend
%kcal from fat	30.6 (0.9)	30.1 (1.4)	30.4 (1.1)	0.902
%kcal from carbohydrate	54.3 (0.9)	53.8 (1.6)	55.8 (1.2)	0.356
%kcal from protein	15.1 (0.5)	16.1 (0.8)	13.7 (0.7)	0.143
	TD Adjusted geometric mean (SE)	**ID only Adjusted geometric mean (SE)**	**ID/ASD Adjusted geometric mean (SE)**	***P*-value Test for trend**
Energy (kcal)	1627.4 (1.0)	1579.3 (1.1)	1489.7 (1.0)	0.131
Protein (g)	60.5 (1.0)	60.4 (1.1)	49.1 (1.1)	0.004
Fibre (g)	14.5 (1.1)	12.3 (1.1)	13.6 (1.1)	0.470
Added sugars (g)	46.6 (1.1)	43.6 (1.2)	32.0 (1.1)	0.013

[†]All analyses adjusted for BMI *z*-score, parent education (college and no college) and race (White and non-White).

ASD, autism spectrum disorder; BMI, body mass index; ID, intellectual disability; SE, standard error; TD, typically developing.

Table 5

Micronutrients by group (TD, ID only and ID/ASD)†

Nutrient	TD (n = 55) Adjusted mean (SE)	ID only (n = 18) Adjusted mean (SE)	ID/ASD (n = 30) Adjusted mean (SE)	*P*-value Test for trend
Niacin (mg niacin equivalents)	32.2 (1.3)	30.3 (2.2)	25.5 (1.7)	0.004
Vitamin B_{12} (μg)	4.9 (0.3)	4.3 (0.4)	3.7 (0.3)	0.009
Calcium (mg)	989.0 (56.6)	925.6 (92.7)	872.7 (73.2)	0.217
Phosphorus (mg)	114.5 (44.7)	1075.5 (73.3)	968.0 (57.9)	0.055
	TD Adjusted geometric mean (SE)	**ID only Adjusted geometric mean (SE)**	**ID/ASD Adjusted geometric mean (SE)**	***P*-value Test for trend**
Vitamin A (μg RAE)	647.2 (1.1)	578.5 (1.1)	485.3 (1.1)	0.025
Vitamin D (μg)	6.0 (1.1)	4.9 (1.2)	4.3 (1.1)	0.048
Vitamin E (total α-tocopherol, mg)	5.6 (1.1)	5.4 (1.1)	6.6 (1.1)	0.181
Vitamin K (μg)	60.7 (1.1)	49.0 (1.2)	40.4 (1.2)	0.037
Vitamin C (mg)	61.9 (1.1)	59.7 (1.2)	53.8 (1.2)	0.480
Thiamin (mg)	1.6 (1.1)	1.4 (1.1)	1.3 (1.1)	0.077
Folate (μg DFE)	495.6 (1.1)	434.5 (1.1)	360.4 (1.1)	0.004
Riboflavin (mg)	1.9 (1.1)	1.8 (1.1)	1.6 (1.1)	0.025
Vitamin B_6 (mg)	1.5 (1.1)	1.4 (1.1)	1.3 (1.1)	0.127
Magnesium (mg)	215.5 (1.0)	208.1 (1.1)	209.9 (1.1)	0.716
Iron (mg)	12.5 (1.1)	11.4 (1.1)	10.4 (1.1)	0.055
Zinc (mg)	8.6 (1.1)	8.7 (1.1)	7.2 (1.1)	0.038
Sodium (mg)‡	2386.6 (1.1)	2195.8 (1.1)	1967.1 (1.1)	0.020
Potassium (mg)	1937.9 (1.0)	1902.2 (1.1)	1847.9 (1.1)	0.525

†All analyses adjusted for BMI *z*-score, parent education (college and no college) and race (White and non-White).

‡Does not include table salt.

ASD, autism spectrum disorder; BMI, body mass index; DFE, dietary folate equivalents; ID, intellectual disability; RAE, retinol activity equivalents; SE, standard error; TD, typically developing.

Table 6

Food servings per day: geometric means (SE) and relative mean difference (95% CI) by group (TD and ID)[†]

Food group	TD (n = 55) Adjusted geometric mean	ID (n = 48) Adjusted geometric mean	Relative mean difference(%) (95% CI)[‡]	*P*-value
Total vegetables	1.23 (1.05)	0.54 (1.06)	−51.41 (−67.68, −26.94)	<0.001
Total fruit	1.11 (1.06)	0.75 (1.07)	−29.31 (−54.17, 9.03)	0.12
Total fruit juice	0.34 (1.11)	0.34 (1.12)	−0.60 (−43.40, 74.54)	0.98
Sugar-sweetened beverages	0.20 (1.08)	0.16 (1.09)	−13.78 (−47.03, 40.36)	0.55
Snacks	1.41 (1.04)	1.08 (1.04)	−21.91 (−46.37, 13.69)	0.19

[†] All analyses adjusted for BMI *z*-score, parent education (college and no college) and race (White and non-White).

[‡] Mean difference is presented as per cent change from TD

BMI, body mass index; CI, confidence interval; ID, intellectual disability; SE, standard error; TD, typically developing.

Table 7

Food servings per day: geometric means (SE) and trend test by group (TD, ID only and ID/ASD)[†]

Food group	TD (*n* = 55) Adjusted mean (SE)	ID only (*n* = 18) Adjusted mean (SE)	ID/ASD (*n* = 30) Adjusted mean (SE)	*P*-value Test for trend
Total vegetables	1.24 (1.05)	0.86 (1.15)	0.40 (1.09)	<0.0001
Total fruit	1.11 (1.06)	0.77 (1.18)	0.74 (1.11)	0.141
Total fruit juice	0.34 (1.11)	0.38 (1.27)	0.32 (1.19)	0.861
Sugar-sweetened beverages	0.20 (1.08)	0.12 (1.22)	0.18 (1.14)	0.803
Snacks	1.42 (1.04)	1.32 (1.13)	0.95 (1.08)	0.096

[†]All analyses adjusted for BMI *z*-score, parent education (college and no college) and race (White and non-White).

ASD, autism spectrum disorder; BMI, body mass index; ID, intellectual disability; SE, standard error; TD, typically developing.

Table 8

Healthy Eating Index 2015 by group (TD and ID)[†]

Healthy Eating Index 2015	Maximum score	TD (n = 55) Adjusted mean (SE)	ID (n = 48) Adjusted mean (SE)	Adjusted mean difference (95% CI)[‡]	*P*-value
Adequacy					
Total fruits	5	3.6 (0.2)	3.3 (0.3)	−0.3 (−1.0, 0.4)	0.44
Whole fruits	5	3.8 (0.3)	3.1 (0.3)	−0.7 (−1.5, 0.0)	0.05
Total vegetables	5	2.4 (0.2)	1.2 (0.2)	−1.1 (−1.7, −0.6)	<0.001
Greens and beans	5	1.9 (0.3)	1.0 (0.3)	−0.9 (−1.7, −0.1)	0.03
Whole grains	10	5.2 (0.5)	5.7 (0.6)	0.5 (−1.1, 2.0)	0.56
Dairy	10	8.6 (0.4)	7.4 (0.4)	−1.2 (−2.4, 0.0)	0.04
Total protein foods	5	4.0 (0.2)	3.6 (0.2)	−0.4 (−1.0, 0.1)	0.13
Seafood and plant proteins	5	2.8 (0.3)	1.9 (0.3)	−0.9 (−1.8, 0.0)	0.05
Fatty acids	10	3.3 (0.5)	4.3 (0.5)	1.0 (−0.5, 2.5)	0.17
Moderation					
Refined grains	10	4.5 (0.5)	5.7 (0.5)	1.2 (−0.3, 2.6)	0.12
Sodium[§]	10	5.9 (0.4)	6.8 (0.4)	0.9 (−0.3, 2.1)	0.14
Added sugars	10	7.0 (0.3)	7.5 (0.3)	0.5 (−0.5, 1.4)	0.35
Saturated fats	10	6.0 (0.5)	6.7 (0.5)	0.7 (−0.6, 2.0)	0.29
Total score	100	59.1 (1.9)	58.2 (2.0)	−0.9 (−6.5, 4.7)	0.76

[†] All analyses adjusted for BMI *z*-score, parent education (college and no college) and race (White and non-White).

[‡] Mean difference is presented as difference (ID – TD).

[§] Does not include table salt.

BMI, body mass index; CI, confidence interval; ID, intellectual disability; SE, standard error; TD, typically developing.

Table 9

Healthy Eating Index 2015 by group (TD, ID only and ID/ASD)[†]

Healthy Eating Index 2015	Maximum score	TD (n = 55) Adjusted mean (SE)	ID only (n = 18) Adjusted mean (SE)	ID/ASD (n = 30) Adjusted mean (SE)	*P*-value Test for trend
Adequacy					
Total fruits	5	3.6 (0.2)	3.4 (0.4)	3.2 (0.3)	0.421
Whole fruits	5	3.8 (0.3)	3.2 (0.4)	3.0 (0.3)	0.052
Total vegetables	5	2.4 (0.2)	1.6 (0.3)	1.1 (0.2)	<0.001
Greens and beans	5	1.9 (0.3)	1.4 (0.5)	0.8 (0.4)	0.021
Whole grains	10	5.2 (0.5)	5.0 (0.9)	6.1 (0.7)	0.325
Dairy	10	8.6 (0.4)	7.2 (0.7)	7.5 (0.5)	0.097
Total protein foods	5	4.0 (0.2)	4.0 (0.3)	3.3 (0.2)	0.033
Seafood and plant proteins	5	2.8 (0.3)	2.0 (0.5)	1.8 (0.4)	0.054
Fatty acids	10	3.2 (0.5)	3.0 (0.8)	5.1 (0.7)	0.037
Moderation					
Refined grains	10	4.5 (0.5)	4.5 (0.8)	6.3 (0.6)	0.030
Sodium[‡]	10	5.8 (0.4)	6.2 (0.7)	7.1 (0.5)	0.075
Added sugars	10	7.0 (0.3)	7.1 (0.5)	7.7 (0.4)	0.214
Saturated fats	10	6.0 (0.4)	5.9 (0.7)	7.2 (0.6)	0.113
Total score	100	58.9 (1.9)	54.5 (3.1)	60.4 (2.5)	0.723

[†] All analyses adjusted for BMI *z*-score, parent education (college and no college) and race (White and non-White).

[‡] Does not include table salt.

ASD, autism spectrum disorder; BMI, body mass index; ID, intellectual disability; SE, standard error; TD, typically developing.