A Comparative Analysis of My Plate Food Group Intake to a 3-Day Food Record in Children with Autism Spectrum Disorder

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RESEARCH

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ABSTRACT

Background: Autism Spectrum Disorder (ASD) is a complex developmental disorder impacting 1 in 59 children in the United States and is characterized by social, emotional, communication, and behavioral challenges. Children with ASD commonly exhibit food selectivity due to sensory processing difficulties, aberrant mealtime behaviors, and motor impairment. Previous studies have shown that food selectivity can impact healthy growth and development with implications for nutrient deficiencies.

Method: The objective of this study was to understand the differences of intake and variety of MyPlate food groups between children with an ASD (n=10) and typically developing children (TD) (n=27). An analysis was conducted using the data from a pilot study to develop a comprehensive eating screening inventory named the Sensory Processing, Aberrant Mealtime Behaviors, Motor, and Inventory for Eating (SAMIE). Three-day diet records were analyzed for average daily intake of grains, fruits, vegetable, dairy, and protein using diet analysis software, Nutritionist Pro. Food variety was assessed by categorizing unique food items in each food group.

Results: No differences were found in calories and average daily intake of food groups between ASD and TD, however ASD showed significantly less variety in vegetables ($p=0.04$) and protein ($p=0.03$). Mean differences showed that ASD had less variety in all food groups compared to TD.

Conclusions: This study supports previous findings that children with ASD exhibit more food selectivity and have a limited food repertoire compared to typically developing children.

Key Words: Autism spectrum disorder; Food selectivity; MyPlate.

INTRODUCTION

Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a complex developmental disorder impacting 1 in 59 children in the United States and is four times more likely to affect boys compared to girls [1]. The etiology of ASD is still not well understood reflecting the complexity of the disorder. ASD is characterized by social, emotional, communication, and

behavioral challenges [2] and is diagnosed in all racial, ethnic, socio-economic, and social groups. Along with the core deficits of ASD individuals may have co-occurring diagnoses such as: learning disabilities heightened generalized anxiety, gastrointestinal problems, and sleep disorders [3].

Furthermore, children with ASD commonly exhibit problematic eating and nutrition-related issues. Food selectivity has been the most commonly reported problematic eating behavior and is reported to occur in approximately 90% of children with ASD compared to 25% to 35% in typically developing children [4].

Food selectivity is defined as frequent food refusal, limited food repertoire and high frequency single food intake [5]. Food selectivity in children with an ASD may be impacted by aberrant mealtime behaviors, motor impairments, sensory processing issues related to smells, taste, and texture of foods, [6, 7] restrictive eating habits, [4] and refusal to eat [8]. Studies have shown that children with an ASD consume fewer foods, especially fruits, vegetables, and protein and prefer snack foods, processed foods, and have a higher intake of carbohydrates [8]. It has also been hypothesized that limited consumption of fruits and vegetables, lean meats, and low-fat dairy products related to food selectivity promote increased prevalence of obesity in children with ASD when compared to typically developing children [5, 9, 10]

Schreck and Williams (2006) observed food selectivity in 138 children with an ASD, ages 5-12 years and compared the relationship of feeding problems to family eating preferences. Seventy-two percent of parents in the study reported their child as having restricted acceptance of variety of foods and 57% refusing of non-preferred foods. Children with ASD also exhibited increased food refusal, specific preference for presentation of food and utensils, and adversities to more food textures. Results further illustrated that children with an ASD ate fewer foods in the fruits, dairy, vegetables, and protein groups than family members [9]. It was reported that children with ASD ate fewer than 10 foods from different food groups, even though the families of these children routinely ate a variety food in each food group. Children with ASD preferred foods higher in sugar and fat content [9].

A limitation to consider in this study is that food preferences were reported by the caregiver using a food preference inventory rather than collecting actual data on foods eaten by the child and family members.

Evans and colleagues (2012), observed dietary patterns and weight status of 53 children with an ASD and 58 typically developing children, ages 3-11 years. Parents were asked to complete a food frequency questionnaire (FFQ) to evaluate child intake of fruits, vegetables, fruits and vegetables together, juice, and sweetened non-dairy beverages, snack foods, and energy-dense kids' meals. Children with an ASD consumed significantly more sweetened beverages compared to typically developing children (2.6 ASD, 1.7 TD, p=0.03) and snack foods (4.0 ASD, 3.0 TD, p=0.01). Consumption of fruits and vegetables were also significantly lower (3.1 ASD 4.4 TD, p=0.006) when comparing to typically developing children. Evans and colleagues reported that a limitation in the dietary measurements did not include all dietary risk factors found to be associated with obesity and sampling may have impacted the results.

Current literature illustrates that dietary intake and nutrition quality of children with an ASD differs from that of typically developing children. [11] 252 children with ASD, ages 2-11 years were compared to a matched subset of children without an ASD in the National Health and Nutrition Examination Survey based on age, gender, family income, and race/ethnicity. Autism was confirmed with the Autism Diagnostic Observation Schedule (ADOS). Three-day food records showed that children with ASD consumed lower than recommended intakes of vitamins A, C, D, K, calcium, choline, fiber, magnesium, phosphorus, and potassium from food sources when compared to the control group [11]. Only a few children in both groups met the recommended intake for fiber, choline, calcium, vitamin D, vitamin K, and potassium.

Similar results were confirmed in a study that compared dietary intake between 80 children with ASD to 80 typically developing children between the ages 3 to 9

years of age [12]. Three-day diet records showed low dietary intakes of calcium, magnesium, iron, selenium, folic acid, and vitamin B12 in children with an ASD. Biochemical measurements showed that children with an ASD had statistically lower serum levels of folate, vitamin B12, magnesium, calcium, and iron compared to healthy controls. Interestingly, typically developing children had significantly higher intake of fresh vegetables, milk and dairy products, and eggs but showed no differences in fruit, processed food, junk foods, and whole grains.

Few studies have focused on specific nutrients of interests such as iron, calcium, vitamin D, and vitamin C intake. Studies show that children with an ASD are at greater risk for iron deficiency and iron deficiency anemia than aged matched typically developing peers [13-15] but more evidence is needed and a better understanding if the risk is truly greater than typically developing children. It is hypothesized that iron deficiency in children with ASD is linked to restrictive dietary intake and malabsorption [16, 17]. In a study observing the effects of iron supplementation on sleep and ferritin in 33 children with an ASD 2-6 years of age, Dosman et al. (2007) reported that preschoolers showed greater risk for insufficient dietary iron intake than school-aged children and prevalence does not lessen when the children reach school-age. Due to restricted food preferences, sensory processing with smell, taste, and texture of foods, children with an ASD may be more avoidant of iron rich foods such as meat. There were several limitations of this study, but the greatest was that there was no control group and the small sample size.

Factors that contribute to inadequate levels of vitamin D in children with an ASD may be due to restrictive food preferences with lower consumption of vitamin D rich foods [5], sunscreen use, low maternal vitamin D intake and levels, and mothers with gestational diabetes [18]. Interestingly, a case-control study conducted between 2011 and 2013 explored vitamin D status in 254 ASD cases and 254 controls (ages 3 to 8 years) by blood serum measurement of vitamin D [19]. Among children with ASD, 14.2% had severe vitamin D deficiency (<10 ng/ml), 43.7% had moderate insufficient levels (between 10-20 ng/ml), and 28.3% had milk insufficient levels (between 20-30 ng/ml). In the control group, only 8.3% had severe vitamin D deficiency and showed statistical differences in overall serum levels of Vitamin D (p=0.023).

Additional studies have been conducted and have not shown that vitamin D deficiency is significantly different when compared to typically developing children [20-22]. A possible explanation for the differences in results is the geographical location of the study, pigmentation of skin [23]. Seasonal differences of when the study was conducted [20], acute inflammation [20], and obesity [24].

Neumeyer et al. (2018) conducted a study of 49 boys between 8 to 17 years of age (19 ASD, 19 typically developing controls) and found that children with ASD consumed less calcium from food sources (876.43mg ASD, 1,316.44 typical) ($P < 0.05$) and after supplementation, calcium levels were not corrected in 40-55% of children [25]. Like other studies assessing vitamin D status, this study showed that children with ASD consumed lower amounts of vitamin D (4.62ug of vitamin D) compared to typically developing children (6.35ug). 36.3 % typically developing children met Estimated Average Requirements (EAR) while 12.1% of children with ASD met the EAR for vitamin D [25]. This is statistically significance ($p<.05$) and practical significance exists since vitamin D is necessary for immune function, absorption of calcium, and acts as a mild mood stabilizer.

Adequate consumption of vitamin C requires varied intake of fruits and vegetables and vitamin-C fortified foods. Scurvy, a condition caused by extreme deficiency of vitamin C (<11.4 umol/L), is rare in children in the United States however scurvy has been reported in children with developmental disorders [26- 30). Malhi and colleagues (2017) conducted a study observing feeding difficulties and nutritional adequacy in children with ASD. Sixty-three children with ASD from ages 4 to 10 years were matched to typically developing children by age and socio-economic status. This study revealed that both ASD and control group were found to have inadequate intakes of all micronutrients and had not met the EAR; however, a higher proportion of children with ASD did not meet the EAR for vitamin C (76.2%

ASD, 54% Control) (P = 0.013) [31]. Daily vitamin C intake of the ASD group was 24.04mg/d while typically developing control consumed on 38.65mg/d (P = 0.064). The lower consumption of vitamin C in children with ASD may help to explain lower levels of iron since vitamin C assists in iron absorption. Also, children with ASD had more restricted intake of few foods, particularly vegetables, fruits, and protein despite showing no differences in overall daily calories [31].

Food selectivity is a common feeding problem in all children and can impact growth and development. However, evidence shows that food selectivity is more common in children with ASD. Food selectivity in children with ASD has been associated with increased prevalence of obesity and deficiencies of some micronutrients compared to typically developing children. Professionals are recommended to assess for problematic eating issues to prevent food selectivity and poor growth. All children with ASD should be assessed early in age since most eating habits become habituated by puberty.

MyPlate

MyPlate is a nutritional food guide developed by the U.S Department of Agriculture (USDA) and the U.S. Department of Health and Human Services (HHS) [32]. MyPlate is intended to help healthy Americans become more aware of food choices and to assist individuals in meeting recommended nutrient requirements through the 5 main food groups: fruits, vegetables, grains, proteins, and dairy.

MyPlate recommendations are based on individual height, weight, age, sex, and physical activity level and assume that people will select from all food categories. The USDA recommends that a diet is built on a variety of foods from each food group [33].

SAMIE Study

The Sensory Processing, Aberrant Mealtime Behaviors, Motor, Inventory for Eating (SAMIE) study was a pilot study. The SAMIE is used to screen nutritional risk by identifying the four primary domains that effect eating in children with an ASD: mealtime behavior, eating skills, dietary intake, and sensory processing [3].

Nutrient intakes across the ASD and TD groups were assessed. Means and standard deviations were calculated for total kilocalorie, carbohydrate, fat, protein, cholesterol, saturated fat, monounsaturated fat, polyunsaturated fat, docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA), total fiber, vitamin A, B6, B12, C, D, calcium, sodium, potassium, magnesium, iron, and zinc. A Pearson's correlation test was done to assess the strength of the association between dietary intake standards (Estimated Average Requirements, Recommended Dietary Allowances, and Dietary Reference Intakes) to assist in validating the SAMIE.

Three-day Food Record

The 3-day food record is a commonly used measure to assess dietary intake in clinical practice and research (Kleinman, 2008). Ziegler et al. found that families of children with an ASD were more successful in completing the 3-day food record when compared to a 24-hour recall (Zeigler, 2006). The 3-day food record allows study participants to be trained and use measuring tools and visual aids. It does not rely on memory, and participants can plan a meal in advance that improves accuracy in recording the amount of food that their child has consumed. Since the 3-day food record is most often used in dietary intake studies this measurement tool was selected.

Purpose

The objectives of this study were to understand the differences of dietary intake and variety of MyPlate food groups between children with ASD and typically developing children (TD). Based on a review of literature and results from the SAMIE study, we hypothesized that children with ASD will consume lower amounts of vegetables, dairy, and protein as well as have fewer varieties within these food groups.

METHODS

Participants

An analysis was conducted using the data from the SAMIE pilot study. This study was approved by the University of Northern Colorado Institutional Review Board and supported by the University of Northern Colorado through a Research, Dissemination, and Faculty Development grant. This research project was carried out in accordance with the ethical standards of the responsible committee on human experimentation and with the Declaration of Helsinki as revised in 2000. Informed consent occurred through accessing the research database and reading and signing the consent page. For the original study, the development of the SAMIE the goal was to recruit and enroll primary caregivers to children with an ASD (n=100) or to children who are typically developing (n=100), between the ages of 2-8 years. The age range was chosen due to previous research indicating that feeding behaviors are relatively stable from the age of two until puberty (Cashden, 1998), and that delayed treatment of eating difficulties after the age of eight is associated with growth rates falling below average [10]. Children were excluded from the study if they were diagnosed with other chronic medical diagnoses, intellectual disability, children who were or had received feeding therapy, and if the child was on medication(s) that interfered with typical food intake, or who were consuming a specialized diet. A total of 203 participants completed the online demographic questionnaire and the SAMIE, but only 162 (57 ASD and 105 TD) were included in the analysis since 41 respondents did not meet the inclusion criteria. Out of 162 participants, a total of 10 children with ASD and 27 TD children completed the 3-day food record.

Recruitment of the primary caregivers to children with an ASD occurred through elementary schools, private practitioners, local Autism conferences and local Autism organizations. TD participants were recruited through elementary schools, private practitioners, and word of mouth. As soon as a potential participant clicked on the hyperlink, they viewed the consent form which contained the purpose of the study, inclusion and exclusion criteria, reasons to participate, terms of anonymity and confidentiality, the IRB consent process, incentives for completing the study and how the results will be used to improve the response rate outcome.

MATERIALS & DESIGN

All participants completed the demographic questionnaire, the SAMIE and the 3-day food record via the Qualtrics database. Qualtrics is a secure database server that is a HIPAA compliant research data management system. All collected data was stored in Qualtrics, which represents best-practices for internet-based security. Participants were asked to read and download the 3-day food record training materials and the Microsoft Word version of the 3-day food record. As previously stated, the 3-day food record is a commonly used measure to assess dietary intake in clinical practice and research (Kleinman, 2008). To assure that participants completed the 3-day food record with accuracy, training materials included photographs to assist in estimating portion sizes, common conversions and measurements, an example of a correct 3-day food record and a list of approved abbreviations. The participant was instructed to record 2 weekdays and 1 weekend day for the 3-day food record since weekend days tend to be different for children and their primary caregivers. Once the study participants completed their child's 3-day food record they were instructed to email it to the Primary Investigator and/or upload to Qualtrics.

PROCEDURES AND ANALYSIS

Every participant was asked to complete the demographic information, a brief medical history questionnaire, the SAMIE in Qualtrics and to upload the completed 3-day food record and send via email to the PI. Once the participants completed the study measures, they were directed to a "thank you" page in Qualtrics which re-stated that further contact would be made by the study personnel within 24 hours to address incomplete surveys, to clarify 3-day food record data, and to obtain a mailing address to receive the gift card for completing the study. After the 3-day food record was reviewed and corrections made, the 3-day food record, with an identification number,

was entered into Nutritionist Pro for nutrient analysis by the GRA. To collect test-retest data, the first twenty participants who completed the study were asked to log in to Qualtrics database using the same identification number. Within 48 hours after the follow-up telephone call, they completed the eating screening inventory for the second time and received a second follow-up telephone call to obtain mailing information to receive a compensatory gift card.

Various reports were analyzed using Nutritionist Pro food database. Nutritionist Pro is a research validated food database and is often used to analyze 3-day food records in nutrition research. First, every 3-day food record was inputted into Nutritionist Pro and then the average daily intake of grains, fruits, vegetable, dairy, protein, and calories were analyzed using the MyPlate Analysis in Nutritionist Pro. Second, the MyPlate Summary report that identified the food groups from each food entry was imported into a Microsoft Excel spreadsheet. Third, variations of foods within each food group was then categorized using the list of subgroups available on the USDA website (i.e. Protein: meats, poultry, seafood, eggs, nuts/seeds).33 If the same food was recorded multiples times during the 3-day period, it was only counted as one source of the food group to avoid redundancy. In addition, several types of foods in the same subgroup were also counted as just one source (Example: Food group: Grains – Subgroup: Crackers – Food: Goldfish crackers, Ritz crackers, saltines, etc.) It is important to note that the USDA considers beans and peas as either a source of protein or vegetables depending on individual's total consumption of meat, poultry, and fish. In this study, beans and peas were categorized in the vegetable group as there were no known reports of vegetarian diets in the original data collection. In addition, milk variations other than cow's milk such as, almond milk, were categorized as a protein product rather than dairy in Nutritionist Pro.

Further analysis was conducted to assess the different types of vegetables and protein that children with ASD and TD consume. An aggregated list of all the vegetables and protein were compiled from the 3-day diet records. Percentages of each individual food type were calculated based on the total number of vegetables or protein of the study groups. Finally, an analysis was conducted to compare ASD and TD intake to the USDA MyPlate recommendations for children 4-8 years of age and differences in food group variety.

RESULTS

To better understand the data, means, standard deviations and t-tests were conducted to determine if there were differences in dietary intake and variety of MyPlate food groups when comparing children with ASD to typically developing children. Analysis of the SAMIE study showed participants did not differ between groups for demographic characteristics, therefore making it a homogenous sample. The ratio of males to females in the ASD group was approximately twice as much, which was expected and reflected in other ASD studies since males are five times more likely to be diagnosed with an ASD than females (CDC, 2014).

Food Group Intake between ASD and TD

No differences were found in total kilocalorie intake or daily amounts of all food groups between children with ASD and TD ($p>0.05$) and the effect size was small. However, the ASD group consumed less servings of grains, dairy, and protein. Interestingly, ASD consumed slightly more fruit and vegetables than TD, but only fruit having a large effect size (see Table 1).

Food Group Variety between ASD and TD

Significant differences were found between ASD and TD in the variety of foods in vegetables and protein. ASD had less of a variety in types of vegetables consumed than TD (2.3 vs. 3.5; $p=0.04$) and likewise in the protein group (2.8 vs 3.9; $p=0.03$). Although not statistically different, there were differences in mean variety scores in fruit, dairy, and grains intake between the two groups showing that ASD consumed less of a variety compared to TD. Finally, combining all food groups, ASD consumed on average 17 foods compared to 21.2 foods from TD.

Most Frequently Consumed Vegetables and Protein Intake in ASD and TD

A further analysis was conducted to assess the types of vegetables and proteins more readily consumed by children with ASD and TD. Children with ASD are more likely to eat starchy vegetables like carrots (32.3%) and potatoes (28.4%) and significantly less of other types of vegetables like broccoli (5.8%) and green beans (5.8%). Typically developing children also consumed more carrots (17.5%) and potato (12.5%) in addition to tomato (15%), broccoli (8.3%), and mixed vegetables (6.7%).

In the protein group, the most common types of foods among children with ASD were almond milk (15%), breaded chicken (13.2%), and pepperoni (11.3%). Common foods among typically developing children were peanut butter (17.1%), eggs (10.3%), and meat (7.5%).

MyPlate Recommendations for children 4-8 years of age

To compare food group intake and variety of children with ASD to the USDA age-specific MyPlate recommendations, only the 4 to 8 age group (n=9) was analyzed since there was only one participant between 2 to 3 years of age. These age group cutoffs were determined by the MyPlate daily recommendations for children (Table 3).

Compared to the USDA MyPlate recommendations for children 4-8 years of age, children with ASD (n=9) had inadequate intake of vegetables, diary, and protein but interestingly met the recommendations for daily fruit intake and grain as expected. TD (n=14) met the requirements for grains, fruit, and protein, but did not meet the recommended amount for vegetables and dairy. There were no significant differences between ASD and TD in this age range.

Food Group Variety between ASD and TD age 4-8 years

Similar to the results of the food group variety for all participants, there were significant differences between ASD and TD in the variety of vegetables (p=0.02) and protein (p=0.02). With the exception of fruit which was equal between ASD and TD, mean differences showed that ASD had less variety in all other food groups compared to TD.

DISCUSSION

This study sought to understand the differences of intake and variety of MyPlate food groups between children with ASD and typically developing children. It was hypothesized that children with ASD would consume lower amounts of vegetables, dairy, and protein as well as have fewer variety in these food groups. Children with ASD ate significantly less variety of vegetables and protein groups and on average, had less variety in all food groups than typically developing children.

The USDA recommends choosing a variety of foods and beverages from each food group to build a healthy eating style and to meet calorie and nutrient needs [33] (Agriculture USDA, 2017). However, researchers are finding that children with ASD are eating fewer selections of foods, therefore having a less diversified diet as recommended. This study demonstrated that although children with ASD and TD may have similar amounts of each food group, children with ASD consume fewer sources of foods in each group, particularly in the vegetables and protein groups. Children with ASD showed a stronger preference for starchy vegetables like carrots and potatoes as well as almond milk and breaded chicken for protein. Typically developing children showed frequent consumption of carrots, tomato, potato, peanut butter, eggs, and meat.

Other studies have shown similar results regarding lower vegetable and protein intake in children with ASD [5, 4, 8]. Evans and colleagues (2012) reported children with ASD had different dietary patterns than typically developing children and consumed fewer servings of vegetables (p=0.002) and had higher levels of energy dense foods, such as juice and sweetened non-dairy beverages (p=0.02) and energy-dense snacks (p=0.01). Previous studies have also shown that children with ASD have higher preferences for high calorie foods like fried potatoes and chicken nuggets or other variations of breaded chicken [9, 34]. This is especially concerning since studies show that lower consumption of vegetables and lean meats are related to the increased

prevalence of obesity and comorbidities associated with obesity in children [8-10, 35]

Food selectivity in children with ASD may be related to sensory processing difficulties including oral, tactile sensitivities in addition to aberrant mealtime behaviors and motor impairments [36, 37]. The act of eating requires simultaneous sensory processes, including vision, touch, taste, and smell [38] that may pose as the reason for limited food preferences in children with ASD. In a study that compared food refusal based on characteristics of food, children with ASD refused more foods based on food texture, mixture, brand, shape, and taste/smell than typically developing children (77.4% vs 36.3%; p<0.0001) [39]. Color was significantly associated with refusal of vegetables (p=0.007) and fruit and vegetable intake combined (p=0.01). Schreck et al. (2004) showed that 72% of children with ASD consumed significantly fewer foods from all food groups (p=.001) and was related to food problems such as requiring specific utensils, particular food presentation, and texture.

With higher rates of food selectivity in children with ASD, nutrient adequacy is a common focus in clinical practice and research. Nutritional risk is defined as something that compromises a child's ability to consume a variety of foods and necessary nutrients for healthy growth and development [40]. Conflicting results have been reported on nutritional status in children with ASD. Some studies show no differences exist in dietary intake between children with ASD and typically developing children [41, 42]. Others have found that children with an ASD are inadequate in various nutrients [5, 4] (Bandini et al., 2010; Schreck et al., 2004). Furthermore, studies show that lack dietary variety may be associated with nutrient inadequacy in children [43, 44]. Meng et al. (2018)the association of dietary diversity and food variety with micronutrient inadequacy in children aged 3-17 years (n=2012). The lack of variety in fruits, vegetables, and animal protein groups were correlated with inadequate several micronutrient intakes except for calcium (p <0.05). Additionally, a study that observed food variety in children between 1 to 8 years of age (n=2200) found that limited variety is associated with inadequate calcium (<56%) and folate (<65%) [45]. This study also found that dietary diversity is strongly associated with overall micronutrient adequacy (p<0.0001) and increased variety was positively correlated with anthropometric Z-scores, an indicator of child's growth.

The original results of the SAMIE showed few significant differences in mean dietary intake of macro- and micronutrients between children with ASD and typically developing children however, dietary protein, zinc, and vitamin B12 was significantly correlated with sensory, mealtime behaviors, and eating skill domains ($p < 0.05$). Zimmer et al. (2011) assessed food selectivity in children with ASD and whether selective eating places children at risk for nutritional deficiencies. Selective eaters with autism were significantly more likely to have inadequate for calcium (p=.001), zinc (p=.03), vitamin B12 (p=.03) and vitamin D (p=.001) and inadequate in at least one nutrient ($p = .03$) overall. The study also found that children with autism tried an average of 33.5 foods per month compared to 54.5 foods of a group of age matched typically developing children ($p < .001$). Our study showed similar finding that children with ASD ate fewer varieties in all the food groups as compared to typically developing children (17 vs. 21.1).

Furthermore, evidence suggests that children with ASD have poor calcium intake [11, 13, 16, 46, 47] and may be linked to lower bone density compared to typically developing children [48]. The results for this current study showed that on average, children with ASD between the ages 4 to 8 years consumed below the recommended amount for dairy and generally are more likely to consume milk substitutes such as almond milk. While it was not found to be statistically significant, children with ASD had fewer variety of diary sources than TD (p=0.07). Studies do not show that variety of dairy is related to adequate calcium intake however, specific sources of calcium in the diet of children with ASD should be investigated further.

LIMITATIONS

Several limitations exist with the current study. The first limitation is the small sample size. Only 37 participants

completed a 3-day diet record in the original study. The small sample size inhibits the dietary intake results to be generalized and most likely is not representative of a larger population. Second, the manual organization of food subgroups into Microsoft Excel and grouping similar types of foods within the same subgroups may have impacted the number of foods accounted in each food group. For example, all cookies and crackers were categorized as crackers in the grain group. Third, categorization of some foods items with food groups may differ in Nutritionist Pro than other software. For example, potato chips were considered a vegetable in Nutritionist Pro whereas other studies may consider it a snack food [8]. Fourth, standardized methods for measuring food variety do not exist and is measured differently across studies. Studies have collected information on food variety based on food frequency questionnaires [39, 44], food preference inventory [4], and 3-day diet records [11, 16, 31]

IMPLICATIONS

Future work should focus on validated measures to assess variety and nutrient adequacy in young children with ASD. Studies have shown that the most important time for consuming a healthy diet is before the age of 5 since it is a period of critical brain development (Nyaradi,Li, Hickling, Foster, & Oddy, 2013), therefore children with ASD would benefit from early screening for food selectivity. Better identification of food selectivity by variety would allow professionals to determine the most appropriate macro and micronutrient(s) and foods to target. For example, if a child is only consuming chicken nuggets and french fries from McDonald's restaurant then the registered dietitian or whomever is concentrating on feeding intervention with the child could focus on introducing healthier versions of those two foods so the child with ASD could become familiar with "same but different" and begin eating baked chicken nuggets and homemade french fries and eventually expand those foods to a baked chicken breast and a baked potato. Another important consideration is that the results of this study showed children with ASD lacked variety in all food groups which may justify supplementing a multivitamin, vitamin D, and calcium while food variety is improving and to assist in preventing nutritional deficiencies.

Nutrition management of children with ASD is a challenge due to the complexities of the disorder. Although children with ASD show no differences in daily caloric intake many professionals may think they are not at nutritional risk, but this small secondary analysis illustrates that a lack of variety in nutrient dense foods in food groups is occurring in children with ASD. Over time the lack of variety in nutrient dense foods could impact healthy human growth and development and ultimately lead to diminished health in adulthood. Convincing evidence has shown that individuals who consume a variety of fruits and vegetables reduce risk of chronic diseases [49]. Based on our findings, this is problematic since children with ASD lack a variety of intake in vegetables. A diet rich in lean protein promotes satiety and has a role in body-weight management and changes in favor of lean body mass opposed to adipose (fat) [50]. It is well supported in the literature and in this study that children with ASD lack a variety of lean proteins and prefer fried chicken nuggets as the primary source of protein. The lack of a variety of lean protein intake throughout adolescents and young adulthood could contribute to higher rates of obesity and the co-morbidities associated with overweight and obesity. As previously stated, this is another reason it is important to better understand food intake and the variety within food groups for children with ASD.

Today, little is known why children with ASD food are selective and what it means to grow into the selectivity, but the current data clearly shows a need for larger trials to be conducted. Children with ASD as being reported by caregivers to be "picky" eaters should be screened for food selectivity and dietary variety to ensure nutrient adequacy and healthy growth and development.

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Conflict of Interest

There were no conflicts of interests of any type.

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TABLES

Table 1: Average intake of food groups between ASD and TD.

	ASD (10)	Std. Deviation	TD (27)	Std. Deviation	p-value	*d*
Kcal	1619	367.4	1607	332	0.93	0.03
Grains (oz)	5.6	1.5	5.7	2	0.84	-0.06
Fruit (cup)	1.8	1	1.2	0.7	0.15	0.69
Vegetables (cup)	0.6	0.6	0.5	0.4	0.66	0.20
Dairy (cup)	1.6	0.9	2	1	0.33	-0.42
Protein (oz)	2.9	1.1	3.4	2.8	0.48	-0.23

Table 2: Average number of food variety in each food group between ASD and TD.

	ASD (10)	Std. Deviation	TD (27)	Std. Deviation	p-value	*d*
Grains	6.5	1.4	6.7	1.6	0.76	-0.13
Fruit	3.3	1.3	4.3	2.7	0.15	-0.47
Vegetables	2.3	1.2	3.5	2.2	0.04	-0.68
Dairy	2.1	1	2.8	1	0.07	-0.70
Protein	2.8	1	3.9	1.4	0.03	-0.90

Table 3: Most consumed vegetables in ASD & TD.

ASD	Percentage
Carrots	32.3
Potato French fries, hash brown, tots 60% Potato Chips 30% Potato Salad 10%	29.4
Broccoli	5.8
Green beans	5.8
Hummus	5.8
Cauliflower	2.9
Corn	2.9
Cucumber	2.9
Lettuce, romain	2.9
Peas, sugar snap	2.9
Pepper, bell	2.9
Tomato, sauce	2.9

TD	Percentage
Carrots	17.5
Tomato, whole, sauce	15
Potato French fries, hash brown, tots 60% Potato chips 13.3% Potato, mashed 13.3% Potato, baked 6.6% Potato, salad 6.6%	12.5
Broccoli	8.3
Mixed vegetables	6.7
Cucumber	5.8
Lettuce, iceberg, romaine	4.2
Green beans	3.3
Beans, baked, refried	2.5
Peas	2.5
Pepper, bell	2.5
Celery	1.7
Corn	1.7
Kale	1.7
Onion	1.7
Zuccini	1.7
Spinach	1.7
Artichoke	0.83
Asparagus	0.83
Avocado	0.83
Basil, pesto sauce	0.83
Cauliflower	0.83
Hummus	0.83
Jicama	0.83
Mushroom	0.83
Pickle, dill	0.83
Seaweed, snacks	0.83
Vegetable, juice	0.83

Table 4: Most consumed protein in ASD & TD.

ASD	Percentage
Almond milk	15
Chicken, breaded	13.2
Pepperoni	11.3
Peanut butter	9.4
Meat, beef	7.5
Chicken, breast	5.7
Ham, deli	5.7
Egg	5.7
Hot dog	5.7
Pork, salami	5.7
Sausage, turkey	3.8
Nuts, mixed	3.8
Sausage, pork	3.8
Hazelnut, spread	1.9
Pork, bratwurst	1.9

TD	Percentage
Peanut butter	17.1
Eggs	10.3
Meat, beef	7.5
Sausage, pork, turkey	6.8
Chicken, breast	5.5
Turkey	5.5
Nut, mixed	4.8
Pepperoni	4.8
Bacon	4.1
Chicken, breaded	4.1
Ham	4.1
Hot dog	4.1
Almonds	2.7
Meatballs	2.7
Pork, loin	2.1
Salmon	2.1
Cashews	1.4
Chicken, drumstick, thighs	1.4
Peanut	1.4
Pecans	1.4
Shrimp	1.4
Sunflower seed butter	1.4
Almond milk	0.7
Chicken, rotisserie	0.7
Seed, chia	0.7
Seed, flax	0.7
Tofu	0.7

PEER REVIEW

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