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Dietary Patterns and Body Mass Index in Children with Autism and Typically Developing Children

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Abstract

To determine whether dietary patterns (juice and sweetened non-dairy beverages, fruits, vegetables, fruits & vegetables, snack foods, and kid's meals) and associations between dietary patterns and body mass index (BMI) differed between 53 children with autism spectrum disorders (ASD) and 58 typically developing children, ages 3 to 11, multivariate regression models including interaction terms were used. Children with ASD were found to consume significantly more daily servings of sweetened beverages (2.6 versus 1.7, p=0.03) and snack foods (4.0 versus 3.0, p=0.01) and significantly fewer daily servings of fruits and vegetables (3.1 versus 4.4, p=0.006) than typically developing children. There was no evidence of statistical interaction between any of the dietary patterns and BMI z-score with autism status. Among all children, fruits and vegetables (p=0.004) and fruits alone (p=0.005) were positively associated with BMI z-score in our multivariate models. Children with ASD consume more energy-dense foods than typically developing children; however, in our sample, only fruits and vegetables were positively associated with BMI z-score.

Keywords

Dietary patterns; pediatrics; obesity; autism spectrum disorders; BMI z-score

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1. INTRODUCTION

Childhood overweight and obesity affect over 30% of children in the United States (Ogden, Carroll, & Curtin, 2010). The consequences of childhood overweight and obesity are significant, including cardiovascular risk factors, type 2 diabetes, menstrual abnormalities, sleep apnea, and psychosocial effects (Must & Anderson, 2003). Overweight and obesity affect children of all races, ethnicities, and socioeconomic strata, including children with chronic conditions and developmental disabilities (Bandini, Curtin, Hamad, Tybor, & Must, 2005; Ogden, et al., 2010). One such group of children evinces autism spectrum disorders (ASD). Estimates from 2006 suggest that ASD affects 1 in 110 children in the United States, a prevalence that has quadrupled over the last two decades (Center for Disease Control and Prevention (CDC), 2009). A few studies have examined the weight status of children with ASD. Analyses of the National Survey of Children's Health have shown the prevalence of obesity among children with ASD was at least as high as among other children (Chen, Kim, Houtrow, & Newacheck, 2009; Curtin, Anderson, Must, & Bandini, 2010). Three other small, nonrepresentative samples have also documented that obesity is common in children with ASD (Curtin, Bandini, Perrin, Tybor, & Must, 2005; Rimmer, Yamaki, Lowry, Wang, & Vogel, 2010; Xiong, Ji, Li, He, & Bo, 2009). Despite these findings that suggest that children with ASD are at risk for overweight and obesity, it is not known whether the risk factors in this population are different from those that have been identified for children overall.

Many studies have investigated the dietary contributors to childhood overweight and obesity (Must, Barish, & Bandini, 2009; Sherry, 2005). Evidence from these studies of typically developing children suggests that dietary contributors to caloric imbalance include increased consumption of sugar-sweetened beverages (Ebbeling, et al., 2006; Lise, Anna, Manon, & Kelly, 2007; Ludwig, Peterson, & Gortmaker, 2001; Wang, Bleich, & Gortmaker, 2008), reduced fruit and vegetable intake (Lin & Morrison, 2002; Sherry, 2005), increased portion sizes (Rolls, Engell, & Birch, 2000; Sherry, 2005), eating more snacks (Piernas & Popkin, 2010), and eating more meals away from home (Taveras, et al., 2005; Thompson, et al., 2004). It remains unknown, however, whether these dietary patterns are obesogenic in children with ASD. One reason why they might not be is that it is frequently reported that children with ASD have unusual eating patterns, which may affect the relationship between dietary patterns and obesity development.

One such eating pattern, selective eating, is characterized by a diet that lacks variety and has been associated with inadequate consumption of foods low in energy density such as fruits and vegetables, lean protein-rich foods, and foods high in fiber (Dovey, Staples, Gibson, & Halford, 2008; Dubois, Farmer, Girard, & Peterson, 2007). Although not uncommon in typically developing children, selective or "picky" eating appears to be more prevalent in children with autism spectrum disorders (Bandini, et al., 2010; Cermak, Curtin, & Bandini, 2010; Emond, Emmett, Steer, & Golding, 2010; Schreck, Williams, & Smith, 2004) and may persist beyond the early childhood period. Children with ASD who exhibit food selectivity have been found to have sensory sensitivity with concomitant aversions to specific colors, smells, temperatures, and textures, and preferences for energy-dense foods (Ahearn, Castine, Nault, & Green, 2001; Cornish, 1998; Dominick, Davis, Lainhart, Tager-Flusberg, & Folstein, 2007; Schreck & Williams, 2006; Schreck, et al., 2004; Whiteley, Rodgers, & Shattock, 2000). Thus, children with ASD who exhibit sensory sensitivity may be predisposed to diets with limited variety that are high in energy dense foods and low in fruits, vegetables, and fiber, putting them at increased risk for overweight and obesity.

The Children's Activity and Meal Patterns Study (CHAMPS) was designed to elucidate the selective eating patterns of children with ASD and to determine whether dietary patterns and overweight and obesity risk factors in this population of children differ from typically developing children. Previously published results from this study indicate that children with ASD exhibited more food refusal overall and more refusal of vegetables than typically developing children and have a more limited food repertoire (Bandini, et al., 2010). Based on these findings, we hypothesized that we would observe higher levels of intake of energy dense foods in children with ASD, and that the associations between dietary patterns and BMI would differ for children with ASD as compared to typically developing children.

2. METHODS

2.1 Participants

Participants in CHAMPS included children with ASD and typically developing children ages 3–11 years. Participants were recruited via outreach to local community programs, on-line postings, existing participant databases at the University of Massachusetts Medical School-Shriver Center, autism support organizations, and with the assistance of the Interactive Autism Network Research Database at the Kennedy-Krieger Institute. Participants were excluded if they had been diagnosed with a disease or disorder that affects dietary and/or physical activity habits (e.g. diabetes, heart disease, or other chronic diseases, significant vision or hearing impairment, chronic GI illnesses that affect food intake, and cerebral palsy), or if they were taking medications known to have an impact on appetite, such as steroids, atypical antipsychotics, mood stabilizers, tricyclic antidepressants, anticonvulsants, and stimulants. Diagnoses of children with ASD were confirmed using the Autism Diagnostic Interview – Revised (ADI-R) (Rutter, Le Couteur, & Lord, 2003). Parents of children with ASD were asked to complete the Vineland Adaptive Behavior Scales (VABS) (Sparrow, Cicchetti, & Balla, 2005) to assess their child’s adaptive functioning as well as the Differential Abilities Scale (DAS) (Elliott, 1990) to assess cognitive ability.

2.2 Anthropometry measures

All study participants (child and at least one parent) completed one study visit during which they were weighed and measured, and parents were asked to complete several questionnaires. Each child and their parent(s) were weighed in light clothing without shoes using a Seca™ portable scale and measured using a wall-mounted stadiometer. If both parents were not present at the study visit, the present parent was asked to obtain the absent parent’s height and weight using a provided form and pre-paid envelope for return by mail. Body mass index (BMI, kg/m^2) was calculated for children and their parents from measures of heights and weights. Children’s gender- and age-specific BMI z-scores and corresponding percentiles were calculated relative to the US CDC 2000 growth charts (Kuczmarski, Ogden, Guo, Grummar- Strawn, & Mei, 2002; National Center for Health Statistics, 2009). Overweight was defined as at or above the 85th percentile, obesity was defined as at or above the 95th percentile, and underweight was defined as less than the 5th percentile (Barlow, 2007; Ogden & Flegal, 2010).

2.3 Dietary patterns measures

Parents were interviewed about their child’s eating habits and completed a demographic questionnaire. Additionally, parents were asked to complete a modified version of the Youth/Adolescent Food Frequency Questionnaire (YAQ), which was originally developed as a self-administered food frequency questionnaire (FFQ) for the Growing Up Today Study (Field, Cmargo, Taylor, & Berkey, 1999) and is based on the original Harvard Food Frequency Questionnaire (Willet, 1998). FFQs have been shown to be a valid indicator of usual food intake during a year (Rockett, et al., 1997). We modified the YAQ to examine dietary patterns and food refusal, and we asked parents to write in foods that were not included on the FFQ if their child ate them at least one time per week over the past year. We evaluated child intake of fruits, vegetables, fruits and vegetables together, juice, and sweetened non-dairy beverages, snack foods, and energy-dense "kids' meals", given their association with obesity in typically developing children. Table 1 outlines the foods included in each dietary pattern.

2.4 Other covariate measures

We collected data on several potential confounders. Physical activity level was measured using an Actical® accelerometer. Information on other covariates was collected via the demographics questionnaire. Child race categories were collapsed to white and non-white. Parental education was dichotomized to college degree or not based on whether either parent had earned a college degree. Number of siblings was collapsed to none and one or more. Using anthropometric data collected on parents during the study visit, parental obesity was considered present if either parent's BMI exceeded 30 kg/m^2 (National Heart Lung and Blood Institute, 1998).

2.5 Statistical Analyses

All analyses were conducted using SAS 9.1 (SAS Institute, Cary NC), with statistical significance set at $p<0.05$. Comparisons between children with ASD and typically developing children were made using t-tests for continuous variables and Chi-square or Fisher's exact test for categorical variables. We evaluated whether age, sex, race, parental obesity, parental education, siblings, and child physical activity level differed between children with ASD and typically developing children. Multivariate analysis of variance (MANOVA) was used to evaluate whether dietary patterns differed between children with ASD and typically developing children. If the overall MANOVA was statistically significant, analysis of variance (ANOVA) was used to determine for each dietary pattern whether children with ASD differed from typically developing children. Fruits and vegetables as a combined category was not included in this analysis as it represents the sum of the fruit and vegetable servings, which precludes its inclusion in a model that contained fruits and vegetables as separate categories. To test our hypothesis that the association between dietary patterns and BMI z-score would differ among children with ASD and typically developing children, we tested the statistical significance of the interaction (cross-product) term between each individual dietary pattern and group (ASD or typically developing) with BMI z-score as the outcome variable. Subsequent multivariable linear models were used to assess the relationship between weight status and dietary patterns, adjusted for confounding variables. We assessed the need to control for potential confounding variables by determining if they were associated with either the dietary patterns or BMI z-score. Variables were retained in the model if their inclusion induced a change in the point estimate greater than 10% (Rothman, Greenland, & Lash, 2008).

3. RESULTS

A total of 111 children completed the study, 53 children with ASD and 58 typically developing children. Table 2 presents participant characteristics. Typically developing children were more likely to have an obese parent ($p=0.03$) and to be an only child ($p=0.05$) compared to children with ASD. Although the difference was non-significant, 9% of typically developing children were obese and 17% of children with ASDs were obese. None of the other characteristics significantly differed between the two groups of children.

The results of the MANOVA indicate that dietary patterns of children with ASD and typically developing children are not the same ($p=0.007$). Table 3 compares the mean number of servings for each dietary pattern between children with ASD and typically developing children and presents the results from the subsequent posthoc ANOVA. Specifically, the estimates suggest that children with ASD had higher levels of consumption of energy dense foods than typically developing children, as they consumed significantly more daily servings of juice and sweetened non-dairy beverages (mean juice and sweetened non-dairy beverages: 2.6 versus 1.7 daily servings, respectively (p=0.02)) and energy-dense snacks (mean snacks: 4.0 versus 3.0, respectively (p=0.01)) and fewer daily servings of vegetables (1.3 versus 2.1, respectively; p=0.002) than did typically developing children. There were no significant differences in the number of “kids’ meals” consumed daily across groups (1.1 meals consumed by children with ASD versus 1.0 meals/day in typically developing children, p=0.36) or fruits (2.2 servings versus 1.8 servings; p=0.13).

We hypothesized that higher level of consumption of energy dense foods, as measured via the modified FFQ, would be differentially associated with BMI z-score in children with ASD as compared to typically developing children. To assess this, we first tested the significance of interaction terms, which tested if the association between each dietary pattern and BMI z-score depended upon autism status. Contrary to our hypothesis, we saw no evidence of statistical interaction for autism status and any of the dietary patterns. Accordingly, we then examined the association between each dietary pattern and BMI z-score in six separate models controlling for autism, a salient feature of our study design. We also controlled for parental obesity in each model given the aforementioned differences between typically developing children and those with ASD. Table 4 presents the results for the dietary pattern analysis from multivariable linear regressions. Fruits and vegetables (p=0.004) and fruits alone (p=0.005) were positively associated with BMI z-score in our multivariate models. Traditionally energy-dense foods, including juice and sweetened non-dairy beverages (p=0.12), snacks (p=0.49), and “kids’ meals” (p=0.65), were not associated with BMI z-score in our sample.

4. DISCUSSION

CHAMPS is the first study, to our knowledge, to examine how dietary patterns affect the weight status of children with ASD compared to typically developing children. Parental reports, clinical reports, and research studies have suggested that children with ASD are selective eaters. Specifically, two studies show that children with ASD have a preference for starchy foods and energy-dense foods such as chicken nuggets, hot dogs, cake, French fries, macaroni, pizza, and ice cream over other food groups (Ahearn, et al., 2001; Schreck & Williams, 2006). Our results are consistent with these findings, in that children with ASD were found to have more energy dense dietary intake patterns compared to typically developing children. On average, children with ASD consumed significantly more juice and sweetened non-dairy beverages and snacks and significantly fewer servings of vegetables than typically developing children.

Although food selectivity might be expected to limit intake and result in inadequate weight gain, we hypothesized that higher intake levels of energy dense foods (juice and sweetened non-dairy beverages, snacks, and “kids’ meals”) and lower intake of fruits and vegetables in children with ASD compared to typically developing children would be associated differentially with BMI z-score across groups. This hypothesis is consistent with the findings that children with ASD prefer energy dense foods (Ahearn, et al., 2001; Schreck & Williams, 2006) along with previous findings that energy dense foods are associated with increased caloric intake (Rolls, Drewnowski, & Ledikwe, 2005). Our results do not support this hypothesis, however. First, in our multivariate analyses, interaction terms between each individual dietary pattern and group (autism status) were non-significant for all food patterns, suggesting that the association between each dietary pattern and BMI z-score does not depend upon autism status. Further, juice and sweetened non-dairy beverages, snacks, and energy-dense “kids’ meals” were not associated with BMI z-score. We considered this to be an unexpected finding given that, on average, children with ASD consumed four servings of snack foods per day and 2.6 servings of juice and sweetened non-dairy beverages and typically developing children consumed three servings of snack foods per day and 1.7 servings of juice and sweetened non-dairy beverages.

The finding that juice and sweetened non-dairy beverages were not associated with BMI z-score in our study is not consistent with several previous studies that have found an association between sugar-sweetened beverage consumption and overweight and obesity (Ebbeling, et al., 2006; Lise, et al., 2007; Ludwig, et al., 2001). A recent study found that sugar-sweetened beverage intake accounts for between 10% to 15% of caloric intake in typically developing children and adolescents in the U.S. (Wang, et al., 2008). Decreasing consumption of sugarsweetened beverages is an established modifiable risk factor for overweight and obesity in typically developing children (Wang, et al., 2008). Additionally, sweetened beverage consumption reduces intake of important nutrients (Vartanian, Schwartz, & Brownell, 2007) and is associated with lower bone density in female adolescents (Wang, et al., 2008). While our results are unexpected, it is possible that our study was not powered to detect this association, that inclusion of sweetened beverages (both with natural and added sugars) in our analysis, as opposed to including only those with added sugars, led to different results, that our sample of typically developing children are different from other typical children, or that these beverages contribute “extra” calories in typically developing children and displace other foods in the diets of children with ASD. Regardless, the finding that children with ASD in our study consumed almost three sweetened-beverages per day suggests that further research is needed to better understand how intakes of juice and sweetened non-dairy beverages affects the long-term health and weight status of this population of children.

Perhaps most unexpected was the finding that fruit intake as well as fruit and vegetable intake were positively associated with BMI z-score when controlling for ASD and parental obesity. We examined the combined fruit and vegetable category because dietary guidance often focus on them as a single dietary target (Must, et al., 2009; Sherry, 2005). We examined them separately as well because other researchers have found that patterns of consumption are often dissimilar for children (Cooke, et al., 2004; Gibson, Wardle, & Watts, 1998). While we did not anticipate that increased fruit and vegetable consumption would be associated with increased BMI z-score in our sample, it may be a chance finding or it may be a result of reverse causation, in that parents of heavier children may encourage greater consumption of fruits and vegetables.

Several limitations of this study are noteworthy. First, our data are cross-sectional, such that we cannot make any conclusions on the directionality or causality of associations between dietary patterns and weight status in these two groups. Further, we did not use a probability sample to select children (parents self-selected based on their interest in their topic of the study), we limited the sample to exclude individuals with chronic disease or illnesses that affect food intake as well as those who take medications that alter appetite, and rates of overweight and obesity in our sample are lower than the national prevalence estimates (Ogden, et al., 2010). Therefore, the generalizability of our findings may be limited. To limit selection bias, we developed recruitment materials that described our study as one designed to explore the mealtime and activity patterns of children with and without autism. It is possible, however, that parents who describe their children as selective or picky eaters or who were concerned about their child’s lack of variety may have been disproportionately attracted to our study. Although we chose to explore the dietary patterns that have been previously identified in the childhood obesity literature (Must, et al., 2009; Sherry, 2005); our dietary measurements did not include all of the dietary risk factors that have been found to be associated with obesity. Furthermore, our instrument did not permit us to separate beverages with added sugars from other non-dairy beverages such as fruit juice. Thus, it is possible that other aspects of diet such as frequency of fast food consumption, sugar-sweetened beverage consumption, and portion size may play a role in obesity development in children with ASD.

5. CONCLUSIONS

Our study examined dietary patterns in children with ASD and typically developing children to determine whether dietary patterns and nutrition-related overweight and obesity risk factors in children with autism differ from typically developing children. Consistent with previous findings on food selectivity in children with ASD, we found that children with ASD consumed significantly more servings of juice and sweetened non-dairy beverages and snacks foods and consumed significantly fewer servings of vegetables than did typically developing children. The finding that juice and sweetened non-dairy beverages, snack foods, and “kids’ meals” were not associated with BMI z-score in our sample, while fruit and fruit and vegetable consumption were associated with BMI z-score is unexpected. Although it is well documented that children’s diets are not consistent with national dietary recommendations (Reedy & Krebs-Smith, 2010), our results suggest that noncompliance with fruit and vegetable recommendations, specifically, appear to be more common in children with ASD. These findings emphasize the need for prospective studies examining risk factors for overweight and obesity development in children with ASD, to better understand if the dietary patterns we observed persist into adolescence and put these children at increased chronic disease risk in adulthood.

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HIGHLIGHTS

- Children with ASD consume more sweetened beverages and snacks than typically developing children
- Children with ASD consume fewer fruits and vegetables than typically developing children
- Sweetened beverages, snack foods, and kids' meals were not associated with BMI z-score
- Unexpectedly, fruits and vegetable consumption was associated with BMI z-score
- More research is needed to examine obesity risk factors in children with ASD

Table 1

YAQ Dietary Pattern Groupings

Dietary Pattern	**Included Foods**
Juice and sweetened non-dairy beverages	Juice, Iced tea, Orange juice, Punch, Soda (non-diet)
Vegetables	Asparagus, Avocado, Beets, Broccoli, Butternut Squash, Carrots, Celery, Corn, Cucumbers, Eggplant, Green beans, Green pepper, Kale, Lima beans, Mixed vegetables, Other cruciferous vegetables, Peas, Red pepper, Salad, Slaw, Spinach, Sprouts, Squash, Tomato, Zucchini
Fruits	Apple, Apple sauce, Apricot, Banana, Berries, Grapefruit, Grapes, Kiwi, Mango, Melon, Nectarine, Orange, Peach, Pear, Pineapple, Plum, Raisins, Strawberry
Fruit & vegetables	All fruits and vegetables listed above
Snacks	Brownies, Cakes, Candy, Chips, Cookies, Crackers, Danish, Donuts, Frozen yogurt, Graham crackers, Granola bars, Ice cream, Jell-O, Milkshakes, Pie, Popcorn, Popsicles, Pop-tarts, Pretzels, Pudding, Trail mix, Twinkies
Kids' Meals	Chicken nuggets, Fish sticks, Grilled cheese sandwiches, Hamburgers, Hotdogs, Macaroni & cheese, Pizza, Tacos, Veggie burger/nuggets

Table 2

Participant characteristics: children with autism spectrum disorders (ASD) and typically developing children

	Typically Developing Children (n= 58)	Children with ASD (n=53)	P value[1]
Age, years: Mean (SD)	6.7 (2.4)	6.6 (2.1)	0.75
VABS Score: Mean (SD)	N/A	71.1 (12.4)	
DAS Score: Mean (SD)	N/A	85.8 (22.1)[2]	
Sex, male (%)	78%	83%	0.47
Race, white (%)	76%	83%	0.35
One or more parent with college degree	81%	81%	0.99
Child is an only child (%)	26%	11%	0.05
Child with 1+ obese parent (%)	56%[3]	35%[3]	0.03
Underweight, <5th percentile BMI (%)	0%	2%	0.48
Overweight, ≥85th percentile BMI (%)	22%	26%	0.62
Obese, >95th percentile BMI (%)	9%	17%	0.09
BMI z-score (SD)	0.52 (0.83)	0.43 (1.16)	0.64
Average Physical Activity Counts per week? (SD)	297,320[4] (98,067)	279,495[4] (97,361)	0.42

[1]P values for differences between groups

[2]n=47

[3]n=55 in typically developing children, n=48 in children with ASD

[4]n=47 in typically developing children, n=35 in children with ASD

Table 3

Comparison of daily servings of dietary patterns between children with ASD and typically developing children (Mean, SD)

Dietary Pattern[1]	**Typically Developing Children (n= 58)**	**Children with ASD (n=53)**	**P value**[2]
Juice and sweetened non-dairy beverages	1.7 (1.5)	2.6 (2.7)	0.02
Vegetables	2.1 (1.3)	1.3 (1.4)	0.002
Fruits	2.2 (1.4)	1.8 (1.6)	0.13
Energy-dense snacks	3.0 (1.6)	4.0 (2.4)	0.01
Kids' meals	1.0 (0.6)	1.1 (0.7)	0.36

[1]See Methods section for definition of dietary patterns

[2]MANOVA results (p=0.007) justified posthoc ANOVA for each dietary pattern between children with ASD and typically developing children. P-values shown are for each ANOVA.

Table 4

Association of individual dietary patterns with BMI z-score[1]

Dietary Pattern[2]	b-coefficient[3]	SE of b-coefficient	p-value
Juice and sweetened non-dairy beverages	0.11	0.07	0.12
Fruit & vegetables	0.12	0.04	0.004
Vegetables	0.14	0.07	0.05
Fruits	0.18	0.06	0.005
Energy-dense snacks	0.03	0.05	0.49
Kids' meals	−0.07	0.15	0.65

[1]Separate multivariate adjusted models controlling for autism status and parental obesity

[2]See Methods section for definition of dietary patterns

[3]Predicted difference in BMI z-score associated with one serving increase