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Nutrition perception, dietary intake, and anthropometric correlations between Autism Spectrum Disorder and typically developing adolescents.

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By

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Contents

Abstract

The adolescent's nutrition perception is reflected in dietary intake and body composition. Obesity is prevalent among adolescents with Autism Spectrum Disorder (ASD). Dietary habits of children with ASD are affected by sensory issues, gastrointestinal factors, and parental provision of diet. This cross-sectional study identifies the relationships among variables for dietary intake, nutrition perception of intake, and anthropometric measurements for adiposity for 19 adolescents, ages 11 to 17, with ASD. Twenty-four children who are typically developing (TD) were assessed to compare all variables for significant differences. Measurements of variables of interest were obtained from the adolescent subjects: a 24-hour recall of dietary intake and a nutrition perception survey via a virtual assessment; and from parents: a single assessment of 1-year food frequency questionnaire and a body composition survey. Statistical analyses included paired-sample t-test to determine differences within and between ASD and TD mean variables. Significant differences between child-reported and parent-reported dietary intake variables determined a higher quality intake by parent report. Pearson's r analyses assessed the correlations among variables. There were no significant inverse correlations for dietary total Healthy Eating Index score and child-reported nutrition perception for health perception. Independent sample t-tests yielded waist-to-height ratio and total nutrition perception significantly higher among ASD subjects than TD, while TD adolescents had a higher reported intake of dietary variables for whole grains and fruits than ASD, supporting prior evidence that ASD children are at a greater risk for obesity.

Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder with complex symptoms and comorbidities unique to an individual.[1] One in 44 individuals are diagnosed with ASD in the United States.[2] Nutrition complexities are associated with ASD and stem from behavior characteristics.[3] Dietary habits of children with ASD are affected by sensory issues, gastrointestinal disorders, and parental provision of diet.[4,5] Oral sensory sensitivity, food neophobia, leaky gut syndrome, and food selectivity are known to affect the quality and quantity of dietary intake.[6–8] Assessments of dietary intake among the ASD population are available and identify a continuous concern for nutritional deficiencies.[9,10] A concern is the prevalence of obesity among the ASD population.[11] By adolescence the ASD child has likely established some independence over food choices and timing of meals.[12] Parental provision of nutrition has cemented fundamental dietary habits, but independence may garner different food choices that challenge appropriate dietary habits.[5] Nutrition perception is reflected in the adolescent child's dietary intake and body composition.[13] Evidence of nutrition perception can be found by assessing dietary intake and body composition for correlations with nutrition perception.

The theoretical framework that supports the present study is the deficit of Theory of Mind (ToM).[14–16] Theory of mind deficit is imperative to this study because ToM demonstrates the ability to understand one's own mind and implement behaviors with the state of emotional cognition. A deficit of ToM affects self-perception. Introspection of one's dietary intake can be hindered by a deficit of ToM and perception of intake may be significantly different than actual dietary intake.

The perspective-taking construct is applicable to this study because there is a common ToM deficit among ASD adolescents to be able to equate self-perception with life choices.[14] This

study assesses ASD adolescents' nutrition self-perception of a healthy dietary intake. The executive function (EF) construct is applicable because EF controls adolescent behaviors, including dietary intake choices.[14] A possible deficit in EF may result in unhealthy dietary behavior that doesn't equate to self-perception.

This cross-sectional study identifies the relationships among variables for dietary intake, nutrition perception of intake, and anthropometric measurements for adiposity for 19 adolescents, ages 11 to 14, with ASD. Twenty-four adolescents who are typically developing meeting the same age requirements as the study group were compared for all variables to determine significant differences. Measurements of variables of interest include a parent-reported assessment of 1-year food frequency questionnaire (FFQ) and a body composition survey; and from the adolescent subjects: a 24-hour recall of dietary intake and a nutrition perception survey via a virtual assessment. Statistical analyses included multiple linear regression analyses to assess the correlations among variables. Paired-sample and independent sample t-tests determined differences between and within grouping categories for ASD and TD mean variables. The objective of this study is to determine an inverse correlation between nutrition perception reported by adolescents with ASD and the quality of their dietary intake. A secondary objective will determine any significant differences between ASD and TD subjects for all mean dietary, perception, and anthropometric variables.

Chapter 1

Review of Literature

Special needs children have unique behaviors, habits, cognitive functions, and personalities. Challenges these children and their families face begin before a diagnosis has been implemented and continue as the family navigates a complex world revolving around their child's disability.[17] Compounding these challenges are atypical eating habits that can be identified during the checklist assessment for an Autism Spectrum Disorder (ASD) diagnosis.[18]

Autism Spectrum Disorder

Autism Spectrum Disorder is a neurodevelopmental disorder with a wide variability of symptoms pertaining to social communication, repetitive behaviors, and specific or restricted interests.[1] The Autism and Developing Disabilities Monitoring (ADDM) Network[19] reported in 2016 the prevalence of ASD among 8-year-old children in the United States affected 1 in 54, or 18.5 per 1,000 children. The total prevalence of children (ages 2-17) with autism in the United States is 1 in 45. The prevalence of boys is 4.3 times higher than the prevalence of ASD among girls.[19] Global prevalence of ASD among children is 1 in 100.[20]

Diagnostic Criteria for Autism Spectrum Disorder

The process for ASD diagnosis includes a psychological evaluation with testing measurements based upon the American Psychiatric Association's Diagnostic and Statistical Manual, Fifth Edition (DSM-5) criteria.[21] The diagnosis for Autism Spectrum Disorder, according to the DSM-5 must meet the requirements for deficits in all three areas of social interaction and communication: social-emotional reciprocity, nonverbal communicative behaviors, and developing, maintaining, and understanding relationships. The diagnosis must

also include at least two of four types of restrictive or repetitive behaviors that include either repetition, inflexibility, fixations, and sensory stimuli responses.

The Autism Diagnostic Observation Schedule, Second Edition (ADOS-2), is the most commonly used modular assessment tool for ASD diagnosis, that assesses communication and social interaction between the examiner and the child.[22,23] The interviewer observes the child's development level, language and communication, behaviors and interests, attention and executive function, and social acuity.[23] The Autism Diagnostic Interview – Revised (ADI-R) is a semi-structured interview assessment tool that utilizes the caregiver or parent to provide the examiner the developmental history and daily functions of the child.[22,23] Both tests have good reliability and validity. Another ASD diagnostic tool is the Childhood Autism Rating Scale (CARS-2), which uses a collaborative approach utilizing teacher and parent reports for diagnostic assessment.[24] The Diagnostic Instrument for Social Communication Disorder (DISCO-11) is a complementary tool used to aid in the diagnosis of ASD via a semi-structured interview to obtain the developmental history of the child, utilizing a wider range of developmental domains, and behaviors specific to autism.[25]

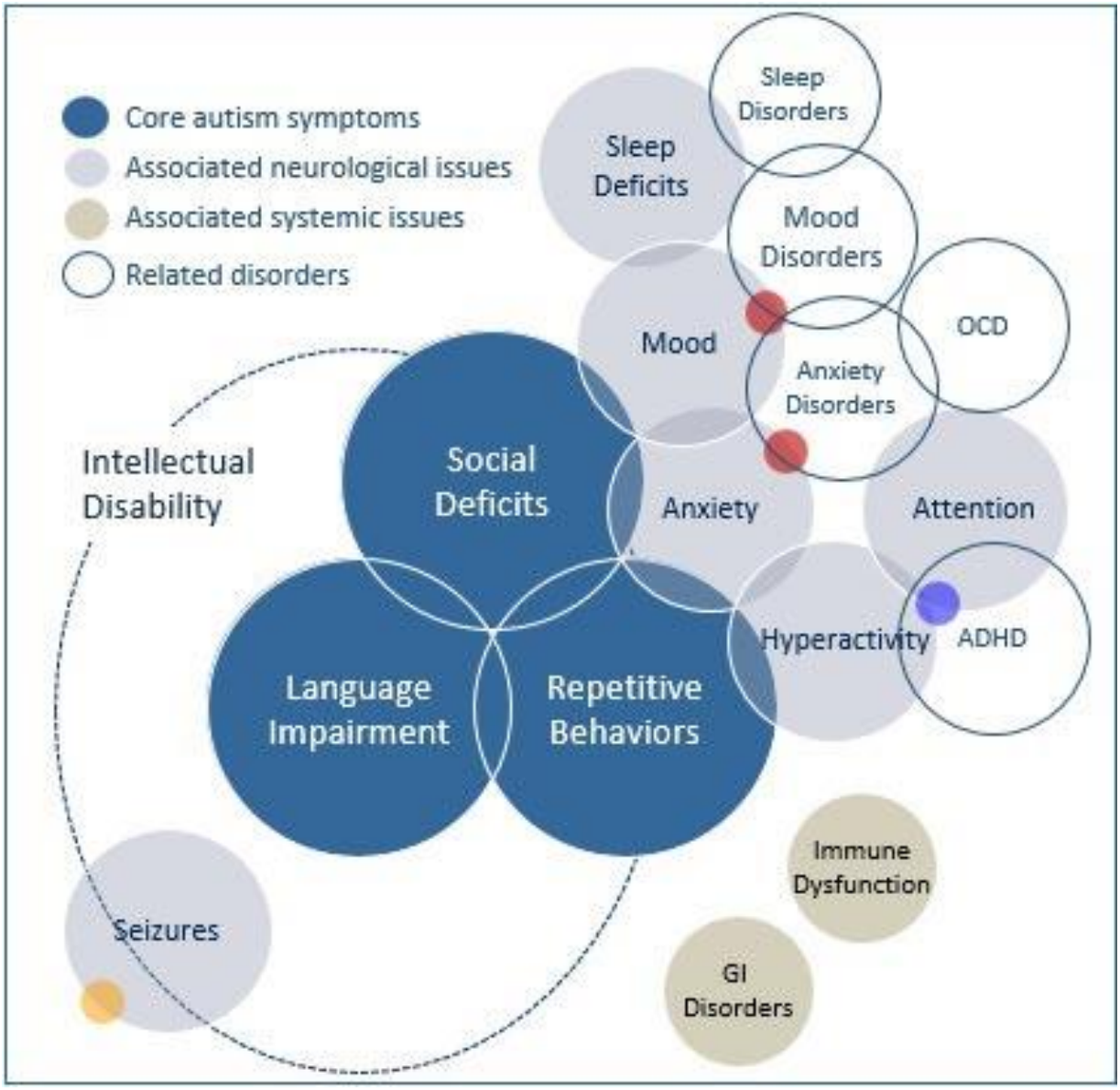
The current diagnostic criteria for ASD does not include a dietary habits assessment. Dietary behaviors may be a consideration as a potential diagnostic tool for ASD especially among the younger pediatric population. Mayes et al[18] identified atypical eating behaviors affected 70.4% of children with ASD. Atypical eating behaviors include food neophobia, limited preferences to food with selective eating, hypersensitivity to texture, temperatures, smells, and flavors, and pocketing or holding food in mouth with delayed swallowing or refusal to swallow food. These behaviors commence as early as infancy.[18] When primary healthcare providers assess children annually, currently dietary intake and mealtime behaviors are not used in early detection criteria

of ASD for infants and toddlers.[26,27] Mayes[18] research suggests that atypical eating behaviors related to ASD and identified early can be an early detector for an autism diagnosis. Early detection allows for early intervention of worrisome eating behaviors thereby limiting adverse health effects from dietary deficiencies.[28]

Characteristics of ASD

Characteristics of autism spectrum vary based on developmental disabilities specific to the individual. There is limited information about what causes autism. Genetic anomalies can identify a commonality for autism, but not all individuals diagnosed with ASD carry a genome specific for autism.[29] Autism is not always physically identifiable among the ASD population. Often individuals with ASD look, speak, and behave the same as typically developing individuals.[3] There are medical or behavior-related co-morbidities commonly associated with ASD. These co-morbidities manifest selectively and individually. They may include sleep disorders, feeding and eating disorders, gastrointestinal disorders, obesity, seizures, attention-deficit/hyperactivity disorder (ADHD), or anxiety .[3]

Figure 1-1. Bubble Chart Identifying Relevant Physiological and Psychological Issues - Autism Spectrum Disorder.[30]



Characteristics of Autism Spectrum Disorder vary as an individualized spectrum of combined physiological and psychological factors. Each characteristic or symptom is associated with nutritional efficacy. Adolescents with ASD, who have not received nutritional intervention by this latent stage of development are at a higher risk for obesity or malnutrition.

Behavioral Characteristics

Challenging or problematic behavior is more prevalent among the ASD population than other children with intellectual disabilities or other psychiatric disorders.[31,32] Problem behaviors are identified by actions that are not socially acceptable, including physically dangerous actions, and any which impede executive functioning.[31] Types of behavior associated with ASD problem behavior include aggression, tantrums or meltdowns, self-injurious behavior, and destruction of property.[31] Without intervention these behaviors increasingly become more severe and occur more frequently as the child grows.[33] The ASD adolescent may become unmanageable and physically unrestrainable with aggressive challenging behavior, therefore, early intervention is necessary.[31]

Interventions to manage problem behavior are implemented with Applied Behavior Analysis (ABA), an evidenced-based treatment for ASD.[31,34] An example of an ABA technique for behavior intervention is positive reinforcement when rewarding a child after they demonstrate good behavior for an identified behavior goal.[35] Antecedent, behavior, consequence (ABCs) are three steps to help teach a child to understand their behavior.[2] The antecedent is the action that occurs before the behavior being targeted for change. An antecedent can be in the form of a request or a command to the child. The subsequent behavior the child elicits determines the consequence in the form of a positive reinforcement for good behavior or no reaction for undesired behavior.[2] Prior to adolescence, a behavior therapy should be implemented for a child with ASD to prevent problematic behavior severity.[31] Social communication, peer interactions, and adaptive skills benefit from early behavior interventions.[35]

Physical Characteristics

Individuals on the autism spectrum usually do not have physical genetic features that set them apart from their typically developing counterpart. ASD is not physically identifiable at first glance.[29] However, there is recent quantitative research that head circumference measurements that are excessive in the first year of life are indicative of individuals diagnosed with ASD later in life.[36] Morphological characteristic abnormalities are prevalent among the ASD population. Ozgen et al[36] assessed quantitative morphological features by measuring height, weight, head circumference, inner and outer canthal distance, ear length, hand length, palm length and shoe size and reported morphological characteristic abnormality prevalence among the ASD population.

Observation of behavior, interactions, communication, and learning abilities is a more common way to identify ASD characteristics.[29] Physical mannerisms, emotional and behavioral changes among adolescents or teenagers with ASD may become more noticeable by junior or senior high school, when social interactions are more predominant.[37] Observable interaction skills that may be challenging for individuals with ASD are hyperactivity/inattention/ impulsivity, aggression, irritability, repetitive behaviors, anxiety, issues surrounding socialization and communication, difficulties surrounding transitions and breaks in expected routines, and fixed interests.[38]

Body Composition

Overweight and obesity is a growing concern for children and adolescents with ASD.[11,39,40] Lack of physical activity is an ongoing concern for children. Sedentary behaviors like video gaming and extensive technology time is associated with weight gain and muscle loss.[39] Children with and without ASD fall prey to sedentary behavior, but children with ASD

may be more prone to decreased physical activity due to social deficits and sensory processing difficulties.[39] There is also some evidence that children with ASD present with lower than average body mass index which may be attributed to food selectivity, higher stress levels increasing exergy expenditure, or taking psychotropic medications.[41]

Co-Morbidities Associated with Autism

Current research is exploring potential biological causes of autism and possible co-morbidities associated with autism. Co-morbidities from mental health disorders to physiological disorder exacerbate the challenges related to ASD. The co-morbidities that are linked to nutrition and health include seizure disorders, eating and feeding challenges, gastrointestinal disorders, sleep disturbances, attention deficit hyperactivity disorder (ADHD), anxiety, depression, schizophrenia, and bipolar disorder.[4]

Seizure Disorders / Epilepsy

Approximately one-fifth to one-third of the autism population suffers from epilepsy. Epilepsy is commonly found among those with an intellectual disability who are identified as having severe autism-like symptoms. Controlling seizures requires anti-epileptic medication that can cause gastrointestinal disturbances.[4] A different treatment for seizure disorder when a child is resistant to anti-seizure medications is the Ketogenic Diet which mimics the fasting state of metabolism and is proven effective in controlling seizures.[42] Although effective among the ASD population, the Ketogenic Diet requires precise regulation of the dietary intake to maintain a state of ketosis for efficacy.

Gastrointestinal Disorders

The gut microbiome among the ASD population produces a myriad of complex symptoms. Abdominal pain, gastroesophageal reflux disease, gas, diarrhea, constipation, and

painful bowel movements are the most common medical conditions associated with ASD. Related symptoms from gastrointestinal disturbances are behavioral symptoms, due to the gut-brain connection,[43] which can exacerbate dietary intake issues.[4] Dietary modifications for some GI-related disorders include adapting to the gluten-free casein-free diet which is an elimination diet with some reported benefits for behavior treatment among the ASD population.[44] Pending research is exploring how probiotics improve the homeostasis of the gut microbiome.[4]

Mental Health Issues

Mental health conditions are prevalent among 54 to 70 percent of individuals with ASD and may be diagnosed at any stage of life.[4,45] ADHD, Schizophrenia, and Bipolar Disorder are neurodevelopmental disorders that manifest in early brain development. Anxiety and depression have latent development usually secondary to autism-related symptoms, life stressors and impaired social skills.[4]

ADHD has a higher estimated prevalence of between 30 to 61 percent among ASD individuals and are characterized with inattentive, hyperactive, and impulsive behaviors that affect social skills and interactions, learning abilities, and daily living. The combination of autism and ADHD yield a higher prevalence of atypical eating behaviors.[18]

Anxiety among ASD can be an underlying cause to resistance that can prevent an adequate dietary intake due to selective food preferences and food neophobia. Anxiety affects 11 to 42 percent of individuals with ASD. Anti-anxiety medications and cognitive behavioral therapies are used to treat anxiety among the ASD population. Depression affects 7 percent of ASD children and progressively increases by age. By the teenage years the rate of depression is 20 percent among ASD individuals and increases to approximately 26 percent by adulthood.[4]

Sleep Disorders

Anxiety among the ASD population can interfere with sleep habits. Over half the autism population of ASD children have sleep disturbances, whether it is trouble falling asleep or staying asleep.[46] Mutations in the genes that regulate the circadian rhythm and seizure disorders both worsen sleep regulation.[4] Sleep disturbances are associated with sensitivities among the ASD population and may affect dietary sensory sensitivities.[46]

Psychotropic Medications and Obesity

Approximately 30% percent of children on the autism spectrum are obese with a 41.1% greater risk of development of obesity.[40] Unhealthy weight gain begins in early childhood.[4] A significant relationship between obesity and psychotropic medications has been reported with a severity of obesity linked to the number of medications.[47] These medications may produce an greater intake of calorically dense, nutritionally deficient foods. Various dietary disorders and deficiencies are associated with obesity and begin with dietary intake habits established in early life.

Nutrition in Autism Spectrum Disorder

The complexities of autism spectrum disorder among children and adolescents affect long-term nutrition and health status. Identification of dietary issues and deficiencies leading to insufficient nutrient intake have guided clinicians to create eating protocols and specialized diets to enable early dietary interventions for this population. However, how a child with autism perceives their dietary intake may hinder their health and nutrition status regardless of established guidelines to prevent prolonged nutrition concerns.

Dietary Issues and Deficiencies

Available research for pediatric ASD and nutrition has limited intervention or observable data for adolescents. Exploratory studies of school age children identified the relationship between dietary problems and ASD even long ago when autism was classified as a mental handicap.[48–51]

Feeding disorders and dietary issues occur when the diet does not provide enough nutrients for health sustainability, or the individual has a physical inability to absorb the required nutrients to thrive.[52] Principal eating behaviors, established in younger children with ASD, that continue throughout adolescence into adulthood include food selectivity or picky eating and food neophobia.[53–56]

Food Selectivity

Food selectivity is not synonymous with picky eating considering some form of picky eating is common among all children and adolescents.[53] Children with ASD have a complicated food selectivity that affects approximately 95% of their pediatric population.[54] Food selectivity among the ASD pediatric population composes a limited variety of foods consumed with rejection of one or more essential food groups.[54] Food selectivity can apply to the refusal of food, the limited intake of preferred foods, or a large intake of a preferred single-food item.[55] Prolonged food selectivity without nutrition intervention to promote a diverse and substantial dietary intake may lead to a risk of nutritional deficiencies including hypocalcemia, low protein intake, water-soluble vitamin deficiencies and gastrointestinal disorders, malnutrition, obesity, or eventual diabetes and possible cardiovascular disease.[6,54]

Food Neophobia

Food neophobia is the refusal to try new or unfamiliar foods.[57] Among the pediatric ASD population, food neophobia falls under the description of food selectivity. The aversion to new foods is common among the pediatric population, especially during early development, but as a child ages, if there is a continued aversion to try new foods, a health risk is imminent with a limited variety of foods.[7] Food neophobia decreases with age for most children. Among the ASD population, food neophobia can remain, increasing the intake of energy-dense foods that have a low nutritional value which lead to weight gain and later cause health concerns including obesity.[57]

Sensory Processing Disorder

Sensory processing difficulties are often found among 45-95% of the ASD population.[56,58,59] Sensory processing is the ability to register, process, and organize sensory information and respond to environmental stimuli appropriately or as an over- or under-sensitive manifestation.[58] Altered sensory perception conditions include indifference to pain, auditory avoidance, texture, visual and olfactory processing sensitivities.[59] Oral sensory sensitivities are also common among ASD.[12]

Oral Sensory Sensitivity

Oral sensory processing dysfunction is related to food selectivity.[58] Atypical oral sensory sensitivity is the underlying component to the food selectivity aversions to texture, taste, smell, and color of foods.[58] Parental reports of what influences food selectivity among children include texture, appearance, taste, smell, and temperature.[56] Fruits and vegetables are usually the primary foods associated with oral sensory sensitivity, likely due to texture.[60] An interdisciplinary

approach to combat oral sensory sensitivities among the ASD population includes referral to occupational or speech therapy that specializes in feeding disorders.[6,60]

Nutrition of Adolescents with ASD

Adolescents with ASD received parental support throughout childhood leading to independence of self-sufficiency for dietary intake. Established dietary intake perception, health habits perception, and self-sufficient behaviors should reflect diet habits. Nutrition education originates in the home.

Dietary Intake

Lower dietary diversity has been established among the ASD pediatric population due to food selectivity, food neophobia, and oral sensory sensitivity. The health risk is substantial when there is a deficiency in essential nutrients which may lead to malnutrition, low bone mineral density, vision loss, scurvy, and failure to thrive.[12] Panossian et al[12] explored the dietary diversity among subjects with autistic-like traits from the longitudinal Raine Study. Dietary intake data, from toddler years and again at age 20, was obtained to determine diversity of intake. The quality of the diet was significantly lower among subjects at age 2 who were identified at age 20 with higher autistic-like traits. Core foods comprised of overall the combination of fruits, vegetables, dairy, grains and cereals, and meats. Core foods, total dietary intake and dairy intake was lower among subjects who represented autistic-like traits. This study addresses the concern for limited nutrient intake among ASD children.

Specifically adolescent nutrition studies among the ASD population are limited.[61,62] Munira et al[62] analyzed the adequacy of nutritional intake among three male age groups, children, adolescents, and adults with ASD. They found the adolescent group had a higher mean carbohydrate intake than the other two groups. All groups, including the adolescent group, had

an inadequate balance of kilocalories and macronutrients and a higher than desirable body weight for age. Feeding behaviors was assessed among the ASD adolescent population in another study[61] and reported there were higher problematic feeding behavior scores correlated with both higher and lower than desired caloric reference ranges.

Gastrointestinal Issues with ASD

A myriad of gastrointestinal (GI) issues among the ASD population are reported. Constipation, diarrhea, abdominal pain, encopresis, bloating, and gastroesophageal reflux disease are indicative of a higher risk for feeding behaviors and are more prevalent among the ASD population compared to the neurotypical population.[63] Research suggests there is a connection between the prevalence of mitochondrial dysfunction, indicated by indirect chemical biomarkers, and ASD.[64,65] A mitochondrial dysfunction affects the ability for the body to meet the demand of cellular energy production, particularly in the GI tract, the central and peripheral nervous system, muscles, and the immune system.[65] These systems are commonly affected among the ASD population. The condition of the enteric microbiome that houses the microbiota specific to the individual is essential to health. Specific foods ingested can alter the enteric microbiome and enhance mitochondrial dysfunction.[65]

Macronutrients

Biological food intolerance affects the ASD population tenfold over the general population with food "allergies" as the general complaint.[66] Postprandial gastrointestinal symptoms are indicative of food intolerance by mast cell activation which releases pro-inflammatory and neurotoxic chemicals. The release causes disruption within the gut-blood-brain barriers affecting the chemical response in the brain leading to behavior that is often found among the ASD population.[66]

Dietary carbohydrates and some proteins ferment in the gut to produce the enteric bacteria *Clostridia* spp. that produces a short-chain fatty acid called propionic acid. Propionic acid has an adverse effect on GI function and is linked to GI inflammation and abnormalities associated with ASD.[65,67]

Previous studies compared the dietary intake of children with ASD with typically developing children and found that the specific macronutrient difference between the two groups was protein consumption.[63,68–71] Children with ASD had a significantly lower consumption of protein than the typically developing cohort. Although adequate protein requirements are met among most ASD children, compared to TD children, protein intake is significantly lower among the ASD population.[63,71,72]

Micronutrients

Vitamins, minerals, and trace elements are essential for the balance in production of enzymes, hormones, and other functional substances in the body.[73] Deficiencies of micronutrients are common with ASD due to food selectivity. Evidence of micronutrient deficiencies are correlated with the individual dietary intake of children with ASD.[63,69,73–75] B vitamins, including thiamine, pyridoxine, and cobalamin, affect behavior when levels are low. They combat oxidative stress, a confirmed etiological mechanism of ASD.[76,77] An oxidative stress biomarker that has been researched and is found to be significantly lower among the ASD is plasma reduced glutathione.[77–80] Glutathione is created from the building blocks of amino acids derived from fruits and vegetables, meats and dairy products.[79] The limited intake of these food sources among the ASD population is a precursor for higher levels of oxidative stress. Supplementation of B vitamins yielded improved behavior and reduced oxidative stress biomarkers among children with neurobehavioral disorders who had deficient levels of these

nutrients.[73,76,81] Deficient levels of B vitamins are associated with a lower level of protein intake.[63] Selective eating and limited variety of dietary intake, while meeting caloric requirements, has been attributed to lower levels of calcium, vitamin D and vitamin E among the ASD pediatric population.[82]

Parental Involvement

Younger children on the autism spectrum rely on parental provision of meals, snacks, and beverages. Dietary habits are formed from the influence of parental provision of food. The parent perception of their child's dietary intake is instrumental when attaining sufficient nutrient variety for their child. Parental awareness of the limited intake and poor mealtime behaviors may increase stress during mealtimes.[5] Training parents to cope with their ASD child's feeding problems should be structured around behavior training to improve feeding and behavior problems and to reduce parent stress.[83] Good mealtime habits established in early childhood from parental provision of nutritional variety and expectation of appropriate mealtime behavior create lasting results into adolescence and adulthood.

Nutrition Guidelines for Special Needs

The connection between diet and ASD behavior and physiological functions is evident. Beneficial treatments and dietary modifications improve conditions associated with ASD. Nutrition guidelines for children with autism spectrum disorder, are subjective to the individual. The approach to determine the common types of feeding difficulties among ASD children begin with the parent report of an observation of a feeding difficulty.[84] After reviewing the patient's medical history, anthropometrics, symptoms, and physical examination, the clinician diagnoses the feeding difficulty and treats the child appropriately. If or when the feeding difficulty

continues, determining the nature of the difficulty and provide a tailored treatment to address appetite limitations, food selectivity, or aversion to feeding.[84]

Feeding Approaches

There are nine recommended feeding approaches for children with ASD.[84,85]

1. Maintain appropriate boundaries.
    a. The parent determines when, where, and what their child eats and the child determines how much they eat.
2. Avoid distractions.
    a. The meal setting should be quiet and contained to the designated dining area of the home.
3. Feed to encourage appetite.
    a. Snacks should be avoided except for water and juice and meal times should be spaced out to 3-4 hour intervals between meals.
4. Maintain a neutral attitude.
    a. Never show anger during mealtimes and refrain from expressing overexcitement, keeping the energy at the mealtime calm and neutral.
5. Limit duration.
    a. The meal should last approximately 30-35 minutes and should begin within 15 minutes of sitting down at the table. Foods prepared should be consumed with no replacements during mealtime.
6. Serve age-appropriate food.

    a. Dietary intake should correspond to age: finger foods for toddlers, plated meat, vegetable, starch combination from childhood on utilizing appropriate utensils.

7. Systematically introduce “novel” foods.
    a. Offer foods repetitively (10-15 times, over time) while respecting aversions to new foods.
    b. Reward with verbal praise for consumption of new foods for toddlers, or small token or sticker for older children.
    c. Never reward with preferred foods for good behavior.
8. Encourage independent feeding.
    a. Toddlers should be provided a spoon at mealtimes.
9. Tolerate age-appropriate mess.
    a. Toddlers may be messy, and parents should prepare for messes with a drop cloth under the child’s chair. Children should be provided a napkin or cloth to wipe their own mouth.

Nutrient Supplementation

Supplementation of specific vitamins and minerals have shown to be effective to improve behavior and cognitive function when the dietary intake lacks to provide essential nutrients. Gastrointestinal disorders, especially intestinal membrane disorders, may benefit from essential fatty acid supplementation. GI problems are common among ASD children and polyunsaturated fatty acid (PUFA) supplementation of omega-3 fatty acids has beneficial effects when consumed daily for an extension of six months to reach stable levels.[81] Low levels of omega-3 fatty acids can reduce the levels of the digestive enzymes lactase, maltase, sucrase causing GI dysfunctions.

A healthier or specialized dietary intake with supplementation of digestive enzymes and omega-3 fatty acids may support the needs for GI correction. Mitochondrial disorders causing GI dysfunctions among ASD have improved with L-carnitine supplementation.[81]

Elimination Diets

Gluten-Free Diet

Gluten is a protein found in wheat, barley, rye, and some types of oats.[86] Generally a gluten free diet is used as a treatment for gluten-related disorders such as celiac disease.[44] Gluten-free is also a popular diet among children with ASD for alleviating GI symptoms such as bloating and diarrhea.[86] There is a potential physiologic sensitivity to gluten prevalent among ASD children. Adopting gluten-free diet modifications has been a trend in recent years with limited research to support a definitive change in behavior or sensory reception among ASD children.[87] A randomized, controlled, single-blinded study[88] analyzed autistic symptoms of children who habitually consumed a gluten-free diet prior to the trial. Two randomized groups were advised to either continue a gluten-free or initiate inclusion of gluten-containing foods for six months. After the intervention period, autistic symptoms were analyzed, and the study reported there were no significant differences between the two groups for autistic symptoms, behaviors, or intellectual abilities.

Parental reports of improved behaviors following the adoption of a gluten-free diet is the driving force behind the trend.[8] Although many have been desperate for alternative approaches for autism treatment, there has been no scientific evidence strong enough to defend the efficacy of a gluten-free diet for children with ASD.[87,89] It is not recommended to begin a gluten-free diet for an ASD child without the supervision of a physician and dietitian due to the potential

negative side-effects such as weight loss and lower intake of essential nutrients, causing nutrient deficiencies.[87]

Casein-Free Diet

Casein is a protein found in milk and milk-products. Along with gluten, casein is metabolized into peptides gluteomorphine and casomorphine that bind to opiate receptors in the central nervous system. The peptides imitate the effects of opiates drugs and when the GI tract is compromised, the peptides leak into the circulatory system breaching the blood-brain barrier, directly causing an opiate-like effect on the brain.[8] A combined gluten-free, casein free diet (GFCF) has been extensively researched, with limited evidence from randomized controlled clinical or intervention trials.[8,87,90,91] A crossover study[92] reported that after six months of a combined gluten-free, casein-free diet, there were no significant changes in reported behaviors or urinary casomorphine levels for children and adolescent ASD participants.

Ketogenic Diet

The ketogenic diet has been adopted as an alternative dietary approach to reduce ASD symptoms. Having beneficial effects on neurological conditions such as epilepsy and pyruvate dehydrogenase deficiencies, the ketogenic diet is sought to be an alternative therapeutic therapy for children with ASD.[86] The ketogenic diet is a carbohydrate-controlled diet with a high fat content and sufficient protein for growth and function. Limiting the carbohydrate intake to reduced levels that do not meet metabolic requirements forces the body to utilize fat as the primary source of fuel. The ketogenic ratio used to be 4:1 fat to combined protein and carbohydrate or 80% fat, 15% protein, 5% carbohydrate with long-chain triglycerides making up most of the fat source.[93] A preferable modified ketogenic diet is the Modified Adkins Diet (MAD) with the initial limitation of carbohydrates for children is 10 grams per day and no limit

to protein or calories.[86] There is limited research to verify the efficacy of the ketogenic diet among ASD pediatric population. One small study[86] compared the ketogenic diet to the GFCF diet and found both diets to correlate with improved CARS scores after six months of intervention. The ketogenic group had better scores in cognition and sociability than the GFCF group.

Adolescent Nutrition Perception

Social functioning and self-preservation rely on an individual's ability to comprehend their own competencies. Self-perception among adolescents with ASD may be impaired or biased. This bias can lead to difficulties with behavior adjustment.[94] Self-perception of individual adolescent autism-related traits[95] and academic performance among ASD adolescents when compared with TD adolescents has been explored.[94] Positively biased self-perception is more prevalent among ASD adolescents compared with TD adolescents.

Perception of the dietary intake for the pediatric ASD population has been surveyed based on the parent's perspective of their child's nutritional intake, mealtime behaviors, and activity participation.[5,96] There is little research about ASD-reported nutrition perception. One study[97] assessed nutrition competence and its association with fine and gross motor skill. Greater nutrition knowledge is positively correlated with motor skills, proposing an influence on body mass index (BMI) among adolescents with ASD. Typically developing adolescents have been assessed on perception of nutrition habits and body composition and found significant differences between the male and female genders' nutritional habits perceptions and perceptions of desired physical composition.[13] One recent study analyzed the ASD adolescent perception of physical activity and even though subjects were aware of the benefits from physical activity, motivation to initiate activity was reported as the greatest struggle.[98] Adolescent perception for

healthy eating interventions was analyzed utilizing focus groups including both adolescents and parents.[99] Both the adolescent and parent groups described healthy eating as having a "balanced diet" with parental emphasis on "clean foods".

Anthropometrics for ASD

Body composition

ASD children quickly gain more weight than children who are typically developing, and are more prevalent to be overweight or obese.[11,39,73] A large sample study[39] compared weight status, physical activity, and sedentary habits of adolescents with ASD to a much larger cohort of typically developing adolescents. The classifications of autism spectrum were represented as mild, moderate, and severe. All categories were large in sample size with mild and moderate generating 87% of the overall sample of ASD adolescents. There were significant differences between the two cohorts for weight status in each of the categories: underweight, normal weight, overweight, and obesity.

Autism and nutrition research has utilized the anthropometrics weight, height, body mass index, bioelectrical impedance analysis, and waist circumference.[11,41,100,101] These anthropometrics provide a source of unambiguous measurements of the body to assess health, and provide diagnostic criteria for obesity and malnutrition, and to measure the progress of fitness from physical activity.[102]

Weight, Height, Body Mass Index

Weight measured in kilograms and height measured in centimeters are standard anthropometric measurements for ASD research, and both are used to analyze body mass

index.[62] BMI is an independent measurement that provides a general measurement for adiposity and malnutrition. Studies have reported significant differences in BMI between children and adolescents with and without ASD.[97,103] Early adolescence with ASD is associated with higher BMI percentages than TD adolescents.

Waist Circumference

Waist circumference (WC) is an anthropometric measurement used to measure adiposity in the abdominal region. Waist circumference used in combination with height for waist to height ratio (WHtR), is a better predictor of adiposity than BMI.[11] WHtR calculations is the waist measurement in centimeters divided by the height measurement in centimeters. The healthy weight cutoff for the quotient of the ratio is 0.5, and anything higher is an indicator of excessive abdominal adiposity with obesity-related health risks.

Role of the Dietitian in ASD

The Registered Dietitian Nutritionists (RDN) works collaboratively with diagnosticians of ASD. The RDN's role is to assess and identify the nutritional risks related to eating habits. Early intervention is necessary when there is evidence of behaviors during mealtimes that indicate a potential for nutrient deficits.

When the ASD child is identified as having feeding difficulties the physician or psychiatrist should refer the child to receive tailored and specialized therapies including feeding therapy with a Speech Language Pathologist and RDN. Parents of younger children should predominantly receive nutrition education as the providers of all meals until independence, if or when it is established.

Parental nutrition education from a RDN is imperative when preventing nutritional risk among ASD children in certain circumstances. Parents who seek guidance from support groups or online forums for autism may be directed on the wrong path for a child, given inadequate information, or encouraged to provide unnecessary supplements to the ASD child. A RDN can help make sense of a complex problem related to an ASD child's dietary habits and tailor nutrition instructions to meet the needs of the individual child.[82]

Statement of the Problem / Gaps in Research

There have been no studies that elaborate on the composition of the ASD adolescent body. Determining that the recommended intake for calories has been met also means there should be analysis of potential underlying health concerns when specific nutrients are not adequately consumed. This study will focus on the adolescent perception of quality of dietary intake. Perceived intake may be inversely correlated with actual intake.

Studies have suggested there is limited intake of protein among the ASD pediatric population when compared with TD children. Research for nutrition perception of adolescents with ASD has not been explored. The correlation of dietary intake, nutrition perception, and abdominal adiposity between children with and without ASD can highlight the differences in early dietary provision. A further analysis of the relationship between dietary intake and perception of intake can provide insight if the perception and intake do not correlate. A higher perception of quality of intake should associate with a diverse and healthful diet. Significant differences between the two variables can aid with early dietary interventions for children with ASD.

Chapter 2

Theoretical Framework

Designing and planning a study, that explores the relationships of perception of intake with dietary intake among the pediatric population diagnosed with special needs, requires constructs for perception and behavior. The theoretical framework for this study will utilize the Theory of Mind (ToM) and determine the deficits of ToM applicable to Autism Spectrum Disorder (ASD).

Theory of Mind

The Theory of Mind was hypothesized and developed by Simon Baron-Cohen as the ability to understand the mental state of others and one's self to make sense of behaviors and then make predictions through perceptions.[15,16,104–106] The ToM conceptualizes that typically developing individuals are continuously analyzing their interpretations of themselves and others. They seek a deeper, more meaningful understanding to explain or predict behaviors.[14] The concept of ToM is a common form of mindreading used in everyday interactions. A subcomponent of social cognition, ToM was developed on the basis that social cognitive abilities make us aware of differing minds with varying beliefs, intuitions, emotions, desires, or intentions. Baron-Cohen later hypothesized that the ability to identify various mental states and make predictions is deficient or impaired among the pediatric autism population.[14,105,106]

Constructs of Theory of Mind

Nonverbal communication is a ToM precursor that begins during infancy when children recognize facial emotions and expressions to develop perceptual components of ToM. Joint attention is the shared interaction between the child and interactor that develops during infancy

and is refined by eighteen months of age when the child shows a clear understanding of the interactor's intentions. ToM evolves from the precursors when language develops after the first year of life. Pretend play helps facilitate ToM utilizing receptive imagination, role assignment, and scenario adaptation.[14]

The precursors trigger ToM development around three to four years of age. Children can distinguish between mental and physical concepts. Mental concepts are subjective, abstract, and intangible, and physical concepts are concrete, visible, and can manifest. These distinctions develop a commonsense conception of causality for emotions or behaviors.

Emotion Cognition

Emotion cognition is a construct of ToM that includes the ability to discern facial expressions, gestures, and verbal cues, then apply sensitivity to the complex content of an interaction.[14,107] Cognition of different emotions, or mixed-emotions is conceptualized in ToM. An example of mixed-emotions is a child both excited and scared to meet Santa Claus for the first time. Another level of emotional cognition includes children applying social norms to behavior. Masking feelings of disappointment or frustration during interactions or social stimuli is applicable.[107]

False-Belief

False-belief is a concept of ToM that demonstrates an inaccurate understanding, or false-belief, of reality. False-belief, considered a trademark for assessing ToM, develops gradually in children, reaching maturity around the age of five.[14,106,107] Theory of Mind tests the false-belief understanding through tasks including The Sally-Anne Test.

Sally-Anne Test

The Sally-Anne Test is a psychological test that poses puppets, so they are tangible, and provides a story to children with the intent to assess false-belief. Children are told about two friends, Sally and Anne, who each have a basket. One friend, Sally, has a ball in her basket and Anne does not. The Sally puppet is temporarily removed from the scenario, the child is told she is going for a walk. The Anne puppet moves the ball into her own basket. Sally returns to the scenario or comes back from her walk. The child is then asked to report which basket Sally will look for her ball. An accurate "belief question" response is where the child believes that Sally will look in her own basket. This indicates that the child is assuming a false-belief of the reality and that Sally's perspective, since she was not present when the ball was moved, is accurate.[106]

Perspective-Taking

An essential Theory of Mind component is perspective-taking. Combining how children see themselves and making life choices is part of perspective-taking. Children should be able to disengage self-perspectives and acknowledge that other individuals have differing perspectives through false-belief application. Empathetic response allows a child to view thoughts, feelings, and behaviors of others by putting themselves in someone else's shoes to perceive that person's responses or intentions.[14] Utilizing the Sally-Anne Test allows for assessment of perspective-taking.

Memory Systems

Memory systems are essential to the development of ToM. Children utilize their memory stores from long-term declarative memory, short-term, source memory, and emotional memory. During early development autobiographical and episodic memory have not been fully engineered, but the ToM constructs are working coincidentally with memory. Working memory

is needed in the development of ToM, as children are able to rely on their memory stores and use them to manipulate internal information for behavior.[14]

Language Development

Language development is also essential to the development of ToM. Early language development has been correlated to ToM development.[14] Simple visual imagery progress into more complex verbal thought throughout ToM. Natural concepts to social concepts occur in stages throughout ToM where children initially use language to identify objects ("ball"), and feelings ("happy" or "sad"), then acquire language to express mental status ("I know", "I feel", "I think"). Language evolves to be utilized appropriately in social context and narrative ability, or giving an account of a story or recall of information. Language development is greatly affected by socioeconomic status and can hinder ToM development.[108]

Executive Function

Executive function (EF) is the process that organizes and controls cognition and behavior.[109] Response suppression, task-switching, and working memory are typical EF that children prospectively master. Executive functioning codevelops with some of the constructs of ToM. Analysis processing, inference, deduction, and estimating are some executive functions that are required for full development of ToM. Although not all executive functions are applied during the process of ToM, some may develop in adulthood.[14]

Social-Environment

Social-environment factors, particularly familial influence, can strongly affect ToM. Parents, siblings, and socioeconomic factors affect the development of ToM. Parents are the first teachers who engage language development and create memories. Siblings create a social environment with play and cooperative tasks. Different cultures and economic status greatly

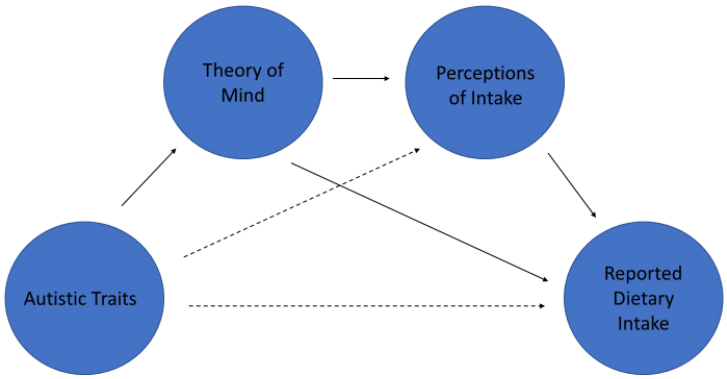
affect the rate of ToM development. Non-traditional households, limited finances, unavailable environmental resources, social deprivation, and mistreatment limit progression of ToM.[14,108]

Deficits of Theory of Mind with Autism Spectrum Disorder

Theory of Mind deficits lead to struggle with explaining self-behavior, explaining other's behavior, understanding emotions, predicting behaviors and emotions, understanding self-perspective, understanding the perspective of others, making inferences, and differentiation between fact and fiction.[16] Theory of Mind perception assessment with The Sally-Anne Task indicates that a child with ASD may not utilize Sally's perception of looking into her own basket to find her ball, and false-belief may be absent as the child uses self-perception in the given scenario.

Emotion cognition, language development, and executive function are constructs with evidence of inhibition among the ASD population. Theory of Mind deficits are apparent with special needs. Baren-Cohen hypothesized that ToM deficit is the debilitation when understanding the perspective of others that the outcome is the observable common deficits in autism with play, communication, and making inferences.[15]

Figure 2-1. Theory of Mind and Autism



The proposed effect of autistic traits on dietary intake, mediated by decreased Theory of Mind (ToM), then increased dietary intake perception, or by decreased Theory of Mind alone, rather than the unexplained effect of autistic traits on intake perception and dietary intake.

Theoretical Framework of Study

Theory of mind deficit is imperative to this study because ToM demonstrates the ability to understand one's own mind and implement behaviors with the state of emotional cognition. A deficit of ToM affects self-perception. Introspection of one's dietary intake can be hindered by a deficit of ToM and perception of intake may be significantly different than actual dietary intake. False-belief of reality is applicable to this study because this study hypothesizes that adolescents have a healthier self-perception of dietary intake than what the measured dietary intake will report.

Perspective-taking construct is applicable to this study because there is a common ToM deficit among ASD adolescents to be able to equate self-perception with life choices. This study will assess ASD adolescents' nutrition self-perception of a healthy dietary intake. The executive function construct is applicable because EF controls adolescent behaviors, including dietary intake choices. A possible deficit in EF may result in unhealthy dietary behavior that doesn't equate to self-perception.

Chapter 3

Methodology

Study Aims

The overall aim for this study was to examine the relationships among the (1) dietary intake, (2) anthropometrics, and (3) perception of nutrition for Autism Spectrum Disorder (ASD) adolescents, while comparing the results with typically developing children (TD).

Primary Research Aims

1. Aim: assess the relationship between the nutrition perception variables and the dietary intake variables within the ASD study group.

   Hypothesis: Adolescents with ASD have a higher perception for nutrition (indicated by a higher NPSQ-9 survey score) that correlates to a diet high in fats and carbohydrates and low in protein, fruits, and vegetables (indicated by a lower Healthy Eating Index score).

2. Aim: assess the comparison of the mean values of all variables for intake, perception, and anthropometrics between TD and ASD groups.

   Hypothesis: Adolescents with ASD are more likely to have either significantly higher or significantly lower adiposity than TD adolescents, significantly higher or significantly lower nutrition perception, and poorer quality of intake.

Study Design

A cross-sectional, quantitative, comparative study was conducted to assess the relationships of dietary intake, anthropometric measurements and perception of nutrition status among and between children with ASD and children who are typically developing. Parental input

on the adolescent's food frequency over one year was collected for assessment and analyzed against the adolescent-reported 24-hour recall of dietary intake. This cross-sectional study design is relevant to ascertain a one-time assessment of adolescent intake with a one-time assessment of perception of intake and anthropometric measurements.

Study Setting

A University of North Florida Institutional Review Board approval was received for this study (*Appendix A*). Initial recruitment of ASD subjects began with distribution of an advertisement flyer. A separate flyer was created to recruit TD subjects. Local and national autism spectrum disorder organizations, behavior facilities, schools, and autism grant benefactors were contacted via email and telephone for recruitment. The flyer had both a website link and QR code link to the study registration.

Physical contact with subjects was not required for this study but made available upon request. A one-time virtual meeting allowed the Principal Investigator to meet with adolescent subjects upon receipt of an informed consent. Virtually, adolescent subjects were provided an electronic verbal assent form in the presence of a parent or guardian prior to dietary intake and nutrition perception assessment.

Participant Recruitment

Children among the ages of 11 to 17 were recruited for this study. The study group included children diagnosed with Autism Spectrum Disorder – Level 1 and Level 2. ASD Level 3 was excluded in this study as these children require substantial communication support. The control group included typically developing children. The exclusion criterion for the control group was any diagnosis of a neurodivergent disorder. The control group was age and gender

matched to the ASD study group. This group was initially recruited from a local private school that has provided a letter of support for this study (*Appendix B*). Recruitment was extended to facilities and social media platforms for special needs that span the United States. When the sample size for participation in the study group was achieved, recruitment for the control group commenced utilizing social media, local private schools, and word-of-mouth.

The rationale for choosing adolescents in this study was to determine the established dietary behaviors and nutrition perception of children who are at an age of independence. Early onset of parental dietary influence is measured during adolescence. ASD adolescents have a higher prevalence of obesity than typically developing adolescents. Utilizing a control group of age and gender-matched TD adolescents aided the study comparisons of all variables.

Data Collection and Measurements

Data from outcomes was obtained from dietary intake questionnaires, anthropometric measurements, and a survey to quantifiably assess nutrition perception. Parents of potential study candidates registered for this study via Qualtrics with detailed study content and requirement information (*Appendix C*). Within 48 hours upon registration, a direct link was emailed for parents to complete the Informed Consent (*Appendix D*), via Qualtrics. The consent form obtained detailed demographic and contact information for prospective correspondence for data collection and measurements. After receipt of an informed consent, the parents emailed the link to complete a Diet Health Questionnaire-III (DHQ-III) food frequency questionnaire (*Appendix E*) reviewing the adolescent's intake over one year. Subsequently, the parents received a link to a Qualtrics survey for anthropometric (body measurements) data (*Appendix F)*. The Principal Investigator mailed a paper tape measure (Wintape 1 meter / 40 inches) with measuring instructions (*Appendix G*) to the home address provided. Parents obtained three separate

measurements of the subject's waist circumference and input the measurements into the Qualtrics survey, along with weight and height measurements obtained from the subject's medical records of well-visits for two most-recent consecutive years. The parents were emailed to schedule a virtual meeting between the Principal Investigator and the adolescent subject, via Zoom, where the child assent was reviewed and completed (*Appendix H*), Automated Self-Administered 24-Hour Recall (ASA24) was obtained (*Appendix I*) for recall of dietary intake, and nutrition perception responses for the modified Nutrition Perception Survey Questioannire-9 (NPSQ-9) survey (*Appendix J*) were obtained.

Diet Health Questionnaire

Daily dietary intake variables were assessed using the DHQIII variables for analysis. The DHQIII obtained parental input of the foods the adolescents had consumed within the previous year with a breakdown of nutrients into daily estimates of nutrient intake. Individually assigned DHQIII password-protected logins were emailed for parental completion and follow-up quantitative analysis.

1. Calculated Healthy Eating Index Score
2. Total daily energy (in kilocalories)
3. Daily protein (in grams)
4. Daily fat (in grams)
5. Daily carbohydrates (in grams)
6. Food categories:
    a. Total daily dairy (in cups)
    b. Total daily animal protein (in grams)
    c. Total daily plant protein (in grams)

d. Total daily fruit (in cups)

e. Total daily vegetables (in cups),

f. Total whole grains (in ounces)

g. Added sugars (in teaspoons)

Automated Self-Administered 24-Hour Recall

To determine validity and reliability of the parental responses for the DHQIII, a 24-hour dietary recall via ASA24 was obtained from the adolescent subject by the PI via interview to provide the same variable analysis. Individually assigned ASA24 logins were utilized by the PI for completion during the virtual assessment and used for follow-up of quantitative analysis.

1. Calculated Healthy Eating Index Score
    a. This score was calculated using the
2. Total daily energy (in kilocalories)
3. Total protein (in grams)
4. Total fat (in grams)
5. Total carbohydrates (in grams)
6. Food categories:
    a. Total daily dairy (in cups)
    b. Total daily animal protein (in ounces)
    c. Total daily plant protein (in ounces)
    d. Total daily fruit (in cups)
    e. Total daily vegetables (in cups)
    f. Total whole grains (in ounces)
    g. Added sugars (in teaspoons)

Anthropometric

A survey, created in Qualtrics for anthropometrics data input, was sent via email link to the parents of subjects to obtain and submit for data analysis:

1. Weight (in kilograms) was self-reported by subject parent/guardian from 2 most recent consecutive physician well-visits.
2. Height (in centimeters) was self-reported by subject parent/guardian from 2 most recent consecutive physician well-visits.
3. Waist circumference (WC) (in centimeters) of the adolescent was obtained by parent/guardian and self-reported. A paper tape measure was mailed to subjects with instructions for proper measurement procedures (see Appendix A).

Nutrition Perception Survey Questionnaire - 9

The Nutrition Perception Survey Questionnaire – 9 (NPSQ-9) (*Appendix J*) was obtained via interview from the adolescent subject by the PI. NPSQ-9 has been modified for this study, addressing any potential adolescent ASD communication complexities. Utilizing a Likert Scale for the survey responses, a test-retest was conducted to ensure internal reliability of the survey modified for this study with a correlation coefficient of 0.86. The total NPSQ-9 score indicates a self-perception of nutrition and health status. The higher the score, the greater the individual's nutrition perception out of a possible total score of seventy-six points.

The four constructs of the NPSQ-9 are:

a. Dietary habits questions ascertain the quantity and quality of foods consumed and preparation methods of foods consumed. In this construct of seven survey questions, the numeric scale of answers to the questions range from 0-2 through

0-5, depending upon the number of possible answer options. The format of this section is multiple choice. An example question: “How many complete meals do you eat in a day?” with answer options “never eat complete meals, only snacks all day” – 0; “One” – 1; “Two” – 2; “Three or more” – 3.

b. Health perception statements are the health locus of control and reflect the efforts and current status of individual health. An example statement: “I am in control of my health.” In this construct of six survey statements, a Likert scale format includes an example response scale for analysis of “completely disagree” – 4; “disagree” - 3; “neither agree or disagree” – 2; “agree” – 1; “completely agree” – 0.

c. Eating perception statements are the self-report eating habits index and reflect the subconscious efforts of healthy eating. An example statement: “Eating healthy is very natural to me.” In this construct of four survey questions, a Likert scale format includes an example response scale for analysis of “completely disagree” – 0; “disagree” - 1; “neither agree or disagree” – 2; “agree” – 3; “completely agree” – 4.

d. Healthy eating management is nutrition self-efficacy and reflects attainability and sustainability of nutrition status. An example statement: “I can stick to eating healthy even if it takes a lot of tries to eat healthy.” In this construct of five survey questions, a Likert scale format includes a response scale for analysis of “very uncertain” – 0; “uncertain” - 1; “certain” – 2; “very certain” – 3.

Variables

Outcomes

1. The primary outcome of interest in this study is a comparison of adolescent dietary intake with adolescent nutrition perception and body composition.
    a. Adolescent dietary intake.
    b. Adolescent nutrition perception.
    c. Adolescent anthropometrics.
2. A secondary outcome of interest in this study is a comparison of all study variables between ASD adolescents and TD adolescents.

Variables of Interest

Table 3-1. Variables of Interest

Dietary	Anthropometric	Nutrition Perception
Healthy Eating Index Scores	Weight (kilograms)	Total Nutrition Perception
Energy (kilocalories)	Height (centimeters)	Dietary Habits
Protein (grams)	Body Mass Index (kilograms/meters$^{2)}$	Health Perception
Carbohydrates (grams)	Waist Circumference (centimeters)	Eating Perception
Fat (grams)	Waist-to-Height Ratio (waist circumference/height)	Healthy Eating Management / Self-Efficacy
Fruits (cups)		
Vegetables (cups)		
Dairy (cups)		
Whole Grains (ounces)		
Added Sugars (teaspoons)		
Animal Protein (ounces)		
Plant Protein (ounces)		

1. Anthropometric variables are measurements to assess adiposity:
    a. Weight (in kilograms) was self-reported by subject parent/guardian from 2 most recent consecutive physician well-visits.

b. Height (in centimeters) was self-reported by subject parent/guardian from 2 most recent consecutive physician well-visits.

c. Body mass index (BMI) was obtained from measured weight and height. **BMI =kg/m^2.**

d. Waist circumference (WC) (in centimeters) of the adolescent was obtained by parent/guardian and self-reported. A paper tape measure was be mailed to subjects with instructions for proper measurement procedures (see Appendix A).

e. Waist-to-height ratio (WHtR) was obtained from measured waist circumference (in centimeters) and reported height (in centimeters), dividing waist circumference by height. The optimal WHtR cutoff for children over the age of six is a quotient of 0.5.[110]

Predictor

Dietary intake may be considered a predictor of anthropometric measurements. Higher fat intake is related to adiposity measurements weight, BMI, waist circumference, and height to waist circumference ratio.[111,112]

Sample Size

Sample size has been calculated using a comparable study[11] for age ASD and TD children via powerandsamplesize.com calculator. The ASD (Group 1) mean Waist Circumference (WC) = 76.29 (12.21) and TD (Group 2) mean WC = 70.84 (10.09). At 80% power, with a 5% error rate is 23 subjects for each group.

Statistical Methods

Statistical Design

This observational, nonexperimental study is intended to identify greater knowledge about dietary perception among adolescent ASD individuals with established nutritional habits. Established dietary habits may promote adverse health outcomes by adolescence. The intent of observation is to lead to future experimentation or interventions of pre-adolescent dietary intake and potential parental nutrition education.

Statistical Analysis

Statistical analysis based on sample size compares three categories of variables for ASD subjects, combining Level 1 and Level 2, and TD subjects. The variables, neither independent nor dependent variables, are based on the interval scale requiring parametric analysis.

This study identifies correlational relationships among the variables of interest. Dietary intake variables were analyzed for correlation with anthropometric variables and diet perception variables within each study group. The variables for anthropometrics were measured for correlation with diet perception within each group. The mean variables for the three sets of categorical variables were compared between both ASD and TD groups. The intended statistical tests to be conducted address the questions of interest.

1. What is the relationship between the dietary perception variables and the dietary intake variables within each study group? The hypothesis states that a higher perception for health and diet correlates to a diet that is has a lower Healthy Eating Index for fats, protein, fruits, and vegetables.

2. What is the comparison of the mean values of all variables between TD and ASD groups? The hypothesis states that adolescents with ASD are more likely to have either significantly higher or significantly lower adiposity than TD adolescents.

Statistical analyses were conducted using IBM SPSS version 28.0 software. Parametric tests were conducted for normal distribution of the interval data. Nonparametric Mann-Whitney U tests were also conducted for comparison but were deemed unnecessary as results were comparable to parametric tests. A simple linear regression test was conducted to analyze the inverse correlations between dietary intake and nutrition perception. Multiple regression was conducted for correlations analyses assessing the relationships of all variables within and among study and control groups. Independent sample t-tests and paired-sample t-tests determined significant differences of mean variables within and between ASD and TD groups.

The Healthy Eating Index variables, from child-reported dietary intake, was calculated from the Automated Self-Administered 24-Hour Recall food and nutrient categorical averages. These averages, entered in an Excel program HEI calculator, analyzed the HEI categorical scores.

Table 3-2. Applying Theoretical Constructs to Statistical Analysis

Theoretical Construct	*Survey / Measurement*	*Statistical Testing*
Perspective-Taking	**NPSQ-9 Survey**: Total score out of 76	Multiple linear regressing analysis
Executive Function	Anthropometrics: **Height**: Individual values Weight: Individual values **BMI**: Individual values **WC**: Individual values **WHtR**: Individual values, Quotient cutoff 0.5	Multiple linear regressing analysis

	ASA24: Daily values of variables **DHQIII**: Daily values of variables

Methodological Challenges

A potential, and likely, challenge for this study was meeting the study sample requirements. Children and adolescents with special needs, including autism spectrum disorder, have sensory issues and may be less inclined to partake in studies where the subjects are required to engage in the requirements for this study. To make the study less invasive, the PI did not require an in-person meeting where physical touch was performed by the PI, rather the parent performed the physical assessment measurements. The familiarity of being at home for a virtual assessment may alleviate any potential anxiety for the adolescent.

Chapter 4

Results

Completed dietary intake surveys, anthropometric measurements including height, weight, waist circumference (WC), body mass index (BMI), waist-to-height ratio (WHtR), nutrition and diet perception surveys were obtained from the study group of adolescent autism subjects ages 11 to 17 (male: n=16, female: n=3) and control group of typical developing adolescents ages 11 to 17 (male: n=12, female: n=12). Table 4-1 provides the descriptive statistics of the two study groups. The study group's autism levels were categorized as Level 1 (n=17) and Level 2 (n=2). Ages of subjects were categorized by levels for the autism study group, ages 11 to 13 (n=7), ages 14 to 17 (n=12), and the control group, ages 11 to 13 (n=7), ages 14 to 17 (n=17). Incomplete or missing subject data from each group (ASD: n=2, TD: n=6) were not included in the statistical analyses.

The Healthy Eating Index variables, from child-reported dietary intake, was calculated from the Automated Self-Administered 24-Hour Recall and parent-reported dietary intake was calculated from the Dietary Health Questionnaire-III food and nutrient categorical averages. These averages, entered in an Excel program HEI calculator, analyzed the child-reported HEI categorical scores. A comparison of both ASD and TD child-reported HEI mean nutrient variables is represented in Figures 4-1 and 4-2.

Table 4-1. Descriptive Statistics of Study Subjects by Age, Gender, and Diagnostic Level

Autism Spectrum Disorder Subjects	n	Typically Developing Subjects	n
Ages		**Ages**	
11 – 13	7	11 – 13	7
14 – 17	12	14 – 17	17
Not reported	0	Not reported	0
Registered with incomplete data. Not included in final analyses.	(2)	**Registered with incomplete data. Not included in final analyses.**	(6)
Total	**n=19**	**Total**	**n=24**
Gender	19	**Gender**	
Male	16	Male	12
Female	3	Female	12
Gender not reported	0	**Gender not reported**	0
Total	**n=19**	**Total**	**n=24**
Autism Level		**Autism Level**	
Autism Level 1	17	Autism Level 0	24
Autism Level 2	2		
Total	**n=19**	**Total**	**n=24**

Figure 4-1. Overlap Child-Reported HEI Chart for Adolescents, Ages 11-17 (ASD and TD)

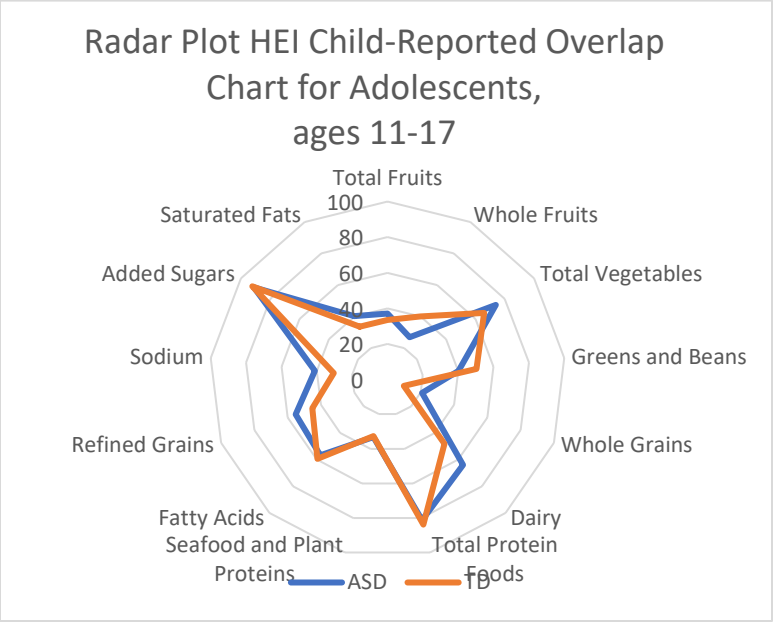
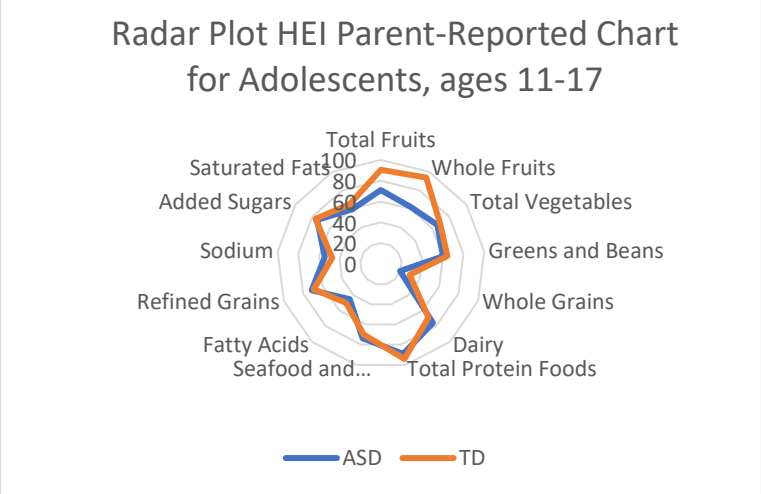


Figure 4-2. Overlap Parent-Reported HEI Chart for Adolescents, Ages 11-17 (ASD and TD)



There are evident differences between the dietary intake for reported Healthy Eating Index categories from child and parent reports. Parent reports for dietary intake cover a one-year span of total intake utilizing the Dietary Health Questionnaire-III, whereas the children's intake was a cross-sectional assessment of the most recent 24-hours of intake.

Table 4-2. Child and Parent Reported Dietary Variables and Means for Autism Adolescents.[1]

Dietary Intake Variables	n	Mean	SD		n	Mean	SD	P value
Child Reported (ASA-24)[2]					**Parent Reported (DHQ-III)[3]**			
HEI Total Fruits	19	1.85	1.89		19	3.55	1.83	**.002**
HEI Whole fruits	19	1.34	1.92		19	3.10	1.82	**.001**
HEI Total Vegetables	19	3.69	1.52		19	3.29	1.42	.141
HEI Greens and Beans	19	2.01	2.28		19	3.01	2.11	.058
HEI Whole Grains	19	2.08	2.79		19	1.95	0.96	.818
HEI Dairy	19	6.40	3.47		19	7.57	2.58	.202
HEI Total Protein Foods	19	4.07	1.13		19	4.46	0.69	.181
HEI Seafood and Plant Proteins	19	1.65	2.22		19	3.68	1.69	**<.001**
HEI Fatty Acids	19	5.69	3.47		19	4.52	2.99	.183
HEI Refined Grains	19	5.52	3.28		19	7.12	2.44	.068
HEI Sodium	19	4.11	3.36		19	5.44	1.99	.173
HEI Added Sugars	19	9.12	1.33		19	7.45	1.63	**.001**
HEI Saturated Fats	19	4.03	3.76		19	5.94	2.99	.089
HEI Total	19	52.8	11.8		19	61.10	13.36	**.015**
Kilocalories (kcals)	19	2759.93	1113.33		19	2107.31	1165.24	**.027**
Protein (grams)	19	100.52	36.83		19	77.41	42.24	.060
Carbohydrates (grams)	19	327.08	154.52		19	280.57	145.60	.210
Total Fat (grams)	19	120.22	53.69		19	78.44	53.30	**.006**
Total Dairy (cups)	19	2.54	1.79		19	2.49	1.88	.911
Total Fruit (cups)	19	0.76	0.78		19	1.85	1.78	**.016**
Total Vegetables (cups)	19	2.34	1.39		19	1.44	0.75	**.005**
Whole Grains (ounces)	19	0.93	1.30		19	.056	0.28	.199
Added Sugars (teaspoons)	19	19.64	18.28		19	15.75	10.66	.357
Animal Protein (ounces)	19	5.45	3.93		19	3.43	2.28	.089
Plant Protein (ounces)	19	0.82	1.28		19	1.17	1.11	.253

1. Values are mean (95% confidence interval)
2. Healthy Eating Index variables from child-reported ASA-24 survey
3. Healthy Eating Index variables from parent-reported DHQ-III survey

Comparisons within the autism study group, between child and parent-provided dietary intake for all Healthy Eating Index (HEI) and individual nutrient or food-category dietary variables (Table 4-2), were assessed with a two-tailed, paired-sample t-test. There were significant paired differences between child and parent reported HEI total fruits (*P*=0.002), HEI whole fruits (*P*=0.001), HEI seafood and plant proteins (*P*=<.001), HEI added sugars (*P*=0.001), Total HEI (*P*=0.015), kilocalories (*P*=0.027), total fat (*P*=0.006), total fruit (*P*=0.016), and total vegetables (*P*=0.005).

Table 4-3. Child and Parent Reported Dietary Variables and Means for Typically Developing Adolescents.[1]

Dietary Intake Variables	n	Mean	SD		n	Mean	SD	P value
	Child Reported (ASA-24)[2]				Parent Reported (DHQ-III)[3]			
HEI Total Fruits	23	1.68	1.90		24	4.55	1.17	**<.001**
HEI Whole fruits	23	2.00	2.30		24	4.69	1.02	**<.001**
HEI Total Vegetables	23	3.30	1.38		24	3.47	1.08	.620
HEI Greens and Beans	23	2.52	2.40		24	3.29	1.89	.205
HEI Whole Grains	23	0.98	2.11		24	2.90	2.44	**<.001**
HEI Dairy	23	4.83	3.03		24	6.68	2.73	**.004**
HEI Total Protein Foods	23	4.19	1.43		24	4.72	.056	.096
HEI Seafood and Plant Proteins	23	1.63	2.14		24	3.41	1.66	**.005**
HEI Fatty Acids	23	5.95	3.20		24	5.21	2.70	.249
HEI Refined Grains	23	4.52	3.05		24	6.75	2.63	**.006**
HEI Sodium	23	3.04	3.40		24	4.61	2.46	.117
HEI Added Sugars	23	9.23	1.48		24	7.64	2.12	**.004**
HEI Saturated Fats	23	3.37	3.40		24	6.62	2.45	**<.001**
HEI Total	23	47.22	10.84		24	64.55	10.68	**<.001**
Kilocalories (kcals)	23	2677.43	1160.91		24	1899.11	897.67	**.003**
Protein (grams)	23	104.26	45.99		24	80.41	43.17	**.006**
Carbohydrates (grams)	23	300.38	153.44		24	242.73	107.89	.076
Total Fat (grams)	23	120.00	52.49		24	71.07	36.76	**<.001**
Total Dairy (cups)	23	1.85	1.75		24	1.94	1.55	.751
Total Fruit (cups)	23	0.76	0.97		24	2.08	1.13	**<.001**
Total Vegetables (cups)	23	2.01	1.07		24	1.41	.062	**.013**

Whole Grains (ounces)	23	0.37	0.72		24	0.72	0.51	**.014**
Added Sugars (teaspoons)	23	18.60	17.34		24	12.73	7.08	.102
Animal Protein (ounces)	23	5.82	3.74		24	4.32	2.87	**.048**
Plant Protein (ounces)	23	0.90	1.49		24	1.05	1.30	.841

1. Values are mean (95% confidence interval)
2. Healthy Eating Index variables from child-reported ASA-24 survey
3. Healthy Eating Index variables from parent-reported DHQ-III survey

Comparisons within the typically developing control group, between child and parent-provided dietary intake for all Healthy Eating Index (HEI) and individual nutrient or food-category dietary variables (Table 4-3), were assessed with a two-tailed, paired-sample t-test. There were significant paired differences between child and parent reported HEI total fruits (P<0.001), HEI whole fruits (P=<0.001), HEI whole grains (P<.0.001), HEI dairy (P=0.004), HEI seafood and plant protein (P=0.005), HEI refined grains (P=0.006) HEI added sugars (P=0.004), HEI saturated fats (P<0.001), Total HEI (P<0.001), kilocalories (P=0.003), protein (P=0.006), total fat (P<0.001), total fruit (P<0.001), total vegetables (P=0.013), whole grains (P=0.014), and animal protein (P=0.048).

Table 4-4. Correlations Among Child-Reported ASD and TD Dietary Intake HEI with Nutrition Perception and Body Measurement Variables.[1]

Variable Correlation	ASD Child-reported HEI (p-values)[2]	Pearson's correlation	TD Child-reported HEI[2] (p-values)	Pearson's correlation
Total Nutrition Perception	.450	-.184	.583	-.121
Nutrition Perception Dietary Habits	.530	-.154	.227	.262
Nutrition Perception Health Perception	.764	-.074	.420	-.177
Nutrition Perception Eating Perception	.861	-.043	.388	-.189
Nutrition Perception Healthy Eating Management	.203	-.306	.260	-.245

Mean Waist Circumference	.831	.052	.417	-.178
Body Mass Index	.734	-0.83	.829	.048
Waist-to-Height Ratio	.785	.067	.840	-.045

1. Values are mean (95% confidence interval)
2. Healthy Eating Index variable from child-reported ASA-24 survey

Pearson's r multiple linear regression was used to analyze the correlations among child-reported ASD and TD dietary intake HEI, child-reported nutrition perception variables and body measures variables (Table 4-4). There were no significant inverse correlations between the child-reported Healthy Eating Index mean totals and child-reported mean health perception totals, nor anthropometric measurements.

Table 4-5. Correlations of ASD Child-Reported HEI Variables with Nutrition Perception Variables.[1]

Variable Correlation	Total Nutrition Perception (p-values)	NP Dietary Habits (p-values)	NP Health Perception (p-values)	NP Eating Perception	NP Healthy Eating Management
HEI Total Fruits[2]	-.295	-.271	-.221	-.163	-.185
HEI Whole fruits[2]	-.296	-.274	-.143	-.256	-.155
HEI Total Vegetables[2]	-.059	.016	-.268	.242	-.214
HEI Greens and Beans[2]	-.401 **(.022)**	**-**.522 **(.024)**	**-**.514 **(.018)**	-.222	-.194
HEI Whole Grains[2]	.207	.235	.0151	.154	.030
HEI Dairy[2]	.406	.200	.208	.366	.364
HEI Total Protein Foods[2]	-.338	-.279	-.092	-.356	-.213
HEI Seafood and Plant Proteins[2]	-.146	.054	-.065	-.032	-.426
HEI Fatty Acids[2]	.023	.016	.435	-.172	-.270
HEI Refined Grains[2]	-.214	-.265	-.409	.046	.029
HEI Sodium[2]	-.276	-.172	-.359	-.023	-.247
HEI Added Sugars[2]	-.178	-.075	-.006	-.191	-.257

HEI Saturated Fats[2]	.226	.212	**.472 (.041)**	-.002	-.082

1. Values are mean (95% confidence interval)
2. Healthy Eating Index variables from child-reported ASA-24 survey (pearson-*r* correlates with significant *p* values)

Pearson's r bivariate regression was used to analyze the correlations among child-reported dietary intake food categories and nutrition perception categories (Table 4-5) among the ASD population. There were significant inverse correlations between the healthy eating index for greens and beans and total nutrition perception (*P*=0.022), dietary habits (*P*=0.024), and health perception (*P*=0.018), and there was a significant correlation between the healthy eating index for saturated fats and nutrition perception of healthy perception (*P*=0.041).

Table 4-6. Comparison of All Variable Means Between ASD and TD.[1]

Variables	n	Mean	SD		n	Mean	SD	P value
	ASD Group				TD Group			
HEI Total Fruits[2]	19	1.85	1.88		23	1.67	1.90	.385
HEI Whole fruits[2]	19	1.33	1.91		23	2.00	2.29	.162
HEI Total Vegetables[2]	19	3.69	1.51		23	3.29	1.37	.188
HEI Greens and Beans[2]	19	2.01	2.27		23	2.52	2.39	.245
HEI Whole Grains[2]	19	2.08	2.78		23	0.98	2.10	**.**075
HEI Dairy[2]	19	6.40	3.47		23	4.82	3.02	.062
HEI Total Protein Foods[2]	19	4.06	1.13		23	4.19	1.43	.377
HEI Seafood and Plant Proteins[2]	19	1.66	2.22		23	1.63	2.13	.485
HEI Fatty Acids[2]	19	5.69	3.46		23	5.94	3.20	.402
HEI Refined Grains[2]	19	5.52	3.28		23	4.51	3.05	.156
HEI Sodium[2]	19	4.11	3.36		23	3.03	3.39	.156
HEI Added Sugars[2]	19	9.11	1.32		23	9.22	1.47	.405
HEI Saturated Fats[2]	19	4.02	3.76		23	3.36	3.40	.276
HEI Total[2]	19	52.84	11.85		23	47.22	10.84	.058
Kilocalories[3]	19	2759.93	1113.33		23	2677.43	1160.91	.409
Protein[3]	19	100.52	36.83		23	104.26	45.99	.388
Carbohydrates[3]	19	327.08	154.52		23	300.38	153.44	.289

Total Fat[3]	19	120.22	53.69		23	120.00	52.49	.494
Total Dairy[3]	19	2.54	1.79		23	1.85	1.75	.108
Total Fruits[3]	19	0.76	0.78		23	0.76	0.97	.490
Total Vegetables[3]	19	2.34	1.39		23	2.01	1.07	.191
Whole Grains[3]	19	0.93	1.30		23	0.37	0.72	**.044**
Added Sugars[3]	19	19.64	18.28		23	18.60	17.34	.426
Animal Protein[3]	19	5.45	3.93		23	5.82	3.74	.379
Plant Protein[3]	19	0.82	1.28		23	0.90	1.49	.429
HEI Total Fruits[4]	19	3.55	1.82		24	4.54	1.17	**.018**
HEI Whole fruits[4]	19	3.09	1.82		24	4.69	1.02	**<.001**
HEI Total Vegetables[4]	19	3.29	1.41		24	3.47	1.08	.315
HEI Greens and Beans[4]	19	3.00	2.11		24	3.28	1.88	.327
HEI Whole Grains[4]	19	1.95	0.96		24	2.89	2.44	.060
HEI Dairy[4]	19	7.56	2.58		24	6.67	2.73	.141
HEI Total Protein Foods[4]	19	4.45	0.69		24	4.72	0.56	.086
HEI Seafood and Plant Proteins[4]	19	3.67	1.68		24	3.41	1.66	.302
HEI Fatty Acids[4]	19	4.51	2.99		24	5.21	2.70	.214
HEI Refined Grains[4]	19	7.12	2.43		24	6.74	2.62	.317
HEI Sodium[4]	19	5.44	1.98		24	4.61	2.45	.119
HEI Added Sugars[4]	19	7.44	1.63		24	7.64	2.12	.369
HEI Saturated Fats[4]	19	5.94	2.99		24	6.62	2.45	.208
HEI Total[4]	19	61.07	13.35		24	64.55	10.68	.174
Kilocalories[5]	19	2107.31	1165.24		24	1899.11	897.67	.256
Protein[5]	19	77.41	42.24		24	80.41	43.17	.410
Carbohydrates[5]	19	280.58	145.60		24	242.73	107.89	.167
Total Fat[5]	19	78.43	53.29		24	71.07	36.76	.297
Total Dairy[5]	19	2.49	1.88		24	1.94	1.55	.148
Total Fruits[5]	19	1.85	1.78		24	2.08	1.13	.301
Total Vegetables[5]	19	1.44	0.75		24	1.41	.062	.444
Whole Grains[5]	19	0.56	0.28		24	0.72	0.51	.109
Added Sugars[5]	19	15.75	10.66		24	12.73	7.08	.136
Animal Protein[5]	19	3.43	2.28		24	4.32	2.87	.138
Plant Protein[5]	19	1.17	1.11		24	1.05	1.30	.375
Total Nutrition Perception	19	54.32	7.80		24	48.29	5.83	**.003**
Nutrition Perception Dietary Habits	19	13.05	2.46		24	11.00	2.99	**.010**
Nutrition Perception Health Perception	19	18.74	3.03		24	18.21	2.57	.270
Nutrition Perception Eating Perception	19	12.16	3.32		24	9.63	2.48	**.003**

Nutrition Perception Healthy Eating Management	19	10.37	2.27		24	9.46	2.32	.102
Mean Waist Circumference	19	75.95	10.20		24	71.34	12.34	.099
Body Mass Index	19	21.56	4.85		24	20.78	2.97	.260
Waist-to-Height Ratio	19	0.46	0.58		24	0.42	0.69	**.034**

1. Values are mean (95% confidence interval)
2. Healthy Eating Index variables from child-reported ASA-24 survey
3. Dietary variables from child-reported ASA-24 survey
4. Healthy Eating Index variables from parent-reported DHQ-III survey
5. Dietary variables from parent-reported DHQ-III survey

Independent sample t-tests (Table 4-6) compared the mean values for all variables analyzed for dietary intake, nutrition perception, and body measurement between the autism spectrum and typically developing adolescent groups. There are significant differences between both groups for the parent-reported HEI total fruits (P=0.018) and whole fruits (P<0.001), child reported whole grains (P=0.044), total nutrition perception (P=0.003), dietary habits (P=0.010) and eating perception (P=0.003) for nutrition perception, and waist-to-height ratio (P=0.034). There are moderate differences between both groups for child-reported HEI whole grains (P=0.075), dairy (P=0.062), and total HEI (P=0.058), parent-reported HEI for whole grains (P=0.060) and total protein foods (P=0.086).

Chapter 5

Discussion

Review of Findings

The purpose of this study was to relate cognizance with dietary actions among diagnosed autism spectrum disorder adolescents while comparing nutrition and health perspectives to adolescents who are typically developing. There is limited research currently available to support the growing trend and need for adolescent autism nutrition analysis. There are no prior studies to demonstrate autistic adolescent perception associating with dietary habits. Children with ASD may present with a dietary intake insufficient to meeting nutrition requirements due to behavioral characteristics, dietary issues or deficiencies.[31,32,58,61,64,113,114] As hypothesized children and adolescents with ASD are at a higher risk for obesity.[11,47,115] This study was primarily intended to demonstrate an inverse correlation between adolescent dietary perception and dietary intake, specifically indicative of lower quality dietary habits when an adolescent on the autism spectrum has a higher perception of a healthful diet as well as to find a correlation between dietary intake and anthropometric measurements.

The first aim of this doctoral project was to determine a correlation for dietary intake, nutrition perception, and anthropometrics of adolescents on the autism spectrum. Both adolescent subjects and their parents provided dietary intake recalls that were analyze for a daily average intake. Parental provision of dietary intake for autism spectrum children has been explored,[5,7,71,116,117] however, no studies have tasked themselves with obtaining dietary intake directly from the child or adolescent to determine a relationship with the adolescent's perception of dietary intake. Prior studies[118,119] have explored the parental and maternal perception of the ASD child's dietary intake, but none indicate ASD adolescent perception. This study is the first

where adolescent subjects for both study and control groups provided a 24-hour recall of intake while the parents completed a one-year account of their child's dietary intake.

Contrary to the hypothesized correlation between ASD child-reported dietary intake and nutrition perception, the results contradict the claim that children with ASD have a higher perception of dietary intake with a lower, child-reported, quality-measured intake utilizing the Healthy Eating Index. Conversely, when utilizing the parent-reported total Healthy Eating Index score, there was a significant inverse correlation between dietary intake and adolescent health habits perception. There were some non-significant, but inverse correlations for total nutrition perception, dietary habits perception, and healthy eating management perception. These results might suggest that the parental report may be a more accurate depiction of a child's lower quality dietary intake, especially where an analysis is longitudinal rather than cross-sectional. The inverse correlations between these variables support the theory that children have a higher perception of their dietary intake than the parent report of their actual intake. We cannot reject the null hypothesis as the aim was to identify correlations based on child reported dietary intake.

To reflect the theoretical framework of this study, a deficit of Theory of Mind indicates that the child lacks the ability to apply the applicable appropriate dietary behaviors regardless of prior knowledge.[106] The parent-reported lower quality of diet with a higher child-reported perception is evidence that this study is supported by deficit of ToM's construct for perceptive-taking.[14] The ASD subjects in this study relayed how they see themselves through both the NPSQ-9 and ASA-24 surveys. The results reflect a false-belief of their reality pertaining to nutrition.

A secondary aim of this study was to conduct a comparison of all dietary intake, nutrition perception and anthropometric measurements between the autism study group and typically

developing control group. The ASD child-reported individual food groups reflect a higher quality diet than their TD child-reported comparisons. This data is countered by the ASD and TD parent report of individual nutrients where whole and total fruits ASD subjects are significantly lower than TD parent-report nutrients, and added sugars and refined grains are noted, but not significantly higher among ASD subjects. The long-term parent-report of dietary intake supports prior studies[11,71,114] that parent-reported dietary intake among ASD school-aged children compared with TD children is a more accurate reflection of a child's dietary intake. This study recognizes the children with ASD had self-reported a higher quality of dietary intake than the TD subjects. This emphasizes the deficit of ToM, that the false-belief of an ADS adolescent's nutrition knowledge, is not necessarily applied to their diet, but they may verbally demonstrate their knowledge of nutrition when surveyed. Therefore, the parent-report effectively identified the correlations and comparisons between and within group differences.

This study data contributes a clear understanding of the concerns with obesity among adolescents with autism. During childhood and adolescence, dietary behaviors resulting in adequate intake are essential for cognitive and physical development.[120] Lower dietary quality habits reflect a greater risk for health problems, especially if obesity is a factor inhibiting development.[47,115,121] This study's analyses yields anthropometric data consistent with concerns for pediatric autism and obesity. One study[11] compares the higher obesity prevalence of ASD school-age children compared with typically developing children. The prior study supports the findings of this study's anthropometric differences between groups where children on with ASD have higher waist-to-height ratio, with mean measurements closer the optimal cutoff for obesity, than their TD comparisons.

Quality intake of individual food groups and nutrients are demonstrated with the comparison between the study and control groups. Previously noted, parental report of dietary intake demonstrates a more accurate depiction of the child's dietary intake supposedly due to the long-term range of assessment. Significant differences are also noted between the study groups for parent-reported dietary intake of nutrients, including whole fruits and whole grains, with ASD children consuming less than TD children. Prior studies[10,45,47,122] have shown fruits and vegetables to be beneficial in preventing obesity.

Limitations

The dietary intake assessment was not well matched between child and parent reports. Adolescent subjects were surveyed using a cross- sectional 24-hour dietary recall while parents provided a long-term annual assessment of intake. The need for a simplified child assessment outweighed the potential of long-term results when considering the autism population's aversion to lengthy assessments, limiting the validity of dietary data.

Conducting this study during the COVID-19 pandemic proved challenging when attempting to recruit the adolescent ASD population for participation. The sample size was small due to limitation in sample size. The PI was able to ascertain parents' and guardians' hesitation to register subjects for one-on-one assessments in person with the Principal Investigator. To alleviate the restriction, the PI changed assessments to virtual meetings. Overall, the recruitment duration of one year yielded a smaller than desired study sample population. Other obstacles during the research process include limited resources for monetary compensation for subject participation and incomplete submission of survey data following multiple requests for completion.

Strengths

Although the Dietary Health Questionnaire-III was intended to provided reliability for the daily nutrient values that the Automated Self-Assessment-24 survey provided, it proved to be useful for child dietary intake analyses as it provided a better assessment of subjects' intake. There was a perceived limitation that was met with considerable success: Level 1 ASD adolescents were receptive to the virtual assessment and provided informative responses to all questions in both dietary perception and intake surveys with minimal guidance from the PI.

Implications to Practice and Research

Implications to Practice

This study advocates for the pediatric autism community. We clinicians need to pay better attention to the early dietary needs of a child with ASD for more than the necessities of behavioral modifications. Early and continuous interventions with dietary recommendations for parents of young children with a neurodivergent diagnosis will allow for inherent dietary behaviors, reducing the risk for chronic diseases prevalent to the population. Early assessment of Autism Spectrum Disorder identifies and establishes interventions for behavioral challenges. Unfortunately, dietary concerns are not typically addressed during the initial phases of autism assessment. Determining food patterns, feeding behaviors, and oral sensitivities by the RDN upon diagnostic onset for autism should be a mandatory referral practice by behavioral psychologists when establishing intervention and recommendation plans. This study was established to identify the cognitive divide between application of dietary perception and habits so RDNs and clinicians may intervene before the onset of health challenges ascribable to poor diet quality.

Implications to Research

The need for nutrition research to match the exponentially growing need to learn more about ASD children and adolescents' dietary habits and hinderances will help with these early dietary interventions for children with autism. Allowing the RDN to assess and collect baseline dietary assessment data could create potential opportunities for longitudinal research analyses. Researchers who establish collaborative data collection with behavioral pediatric practices may enhance future study sample sizes. A qualitative approach to the adolescent ASD nutrition perception has not previously been explored. Utilizing the explorative, quantitative data from the present study, researchers can use the identified significant differences between ASD and TD adolescents dietary, nutrition perception, and anthropometrics, expand on the need for child-reported longitudinal dietary intake assessment, and build a mixed-methods comprehensive analysis of measuring the quantity of dietary intake with a qualitative approach to analyzing nutrition perception among the ASD population.

Conclusion

Understanding how autism spectrum adolescents perceive their dietary intake should continue to be assessed for prevention of nutrient insufficiencies. Evidence of a chasm between how adolescents perceive dietary intake and meeting dietary standards was not demonstrated with an inverse correlation of high perception and lower quality diet in this study. Adolescents with autism are physiologically similar to their typically developing counterparts, but there are evident differences in dietary intake. Although the typical adolescent diet consists of consuming foods inconsistent with meeting health standards, there was concern as to whether the results for autism adolescents would be any different. ASD adolescents may not have the same carefree dietary habits that typically developing adolescents have, but the ASD diet can result from

personal negligence and self-restriction that significant differences between the groups would be indeterminate.

Nutrient variables consistent with preventing obesity, including whole grains and fruits were expected to be higher among typically developing children with correlative high nutrition perception and inverse correlations anticipated from the ASD population. These expectations were met from this study. The next stage is to determine what factors influence this relationship between diet and nutrition perception among the pediatric ASD population and which intervention trials are necessary for conversion of dietary perception and dietary habits. Integration of nutrition education for adolescents with ASD, followed by qualitative analysis to determine factors hindering quality dietary habits is recommended.

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Appendices

Appendix A

UNF
UNIVERSITY of NORTH FLORIDA.

Office of Research and Sponsored Programs
1 UNF Drive
Jacksonville, FL 32224-2665
904-620-2455 FAX 904-620-2457
Equal Opportunity/Equal Access/Affirmative Action Institution

MEMORANDUM

UNF IRB Number: 1773409-2
Approval Date: 09-09-2021
Processed on behalf of UNF's IRB

DATE: September 10, 2021

TO: Ms. Kristin Berg

VIA: Dr. Andrea Arikawa
Nutrition & Dietetics

FROM: Dr. Jennifer Wesely, Chairperson
On behalf of the UNF Institutional Review Board

RE: Review of New Project by the UNF Institutional Review Board
IRB#1773409-2 "Nutrition perception, dietary intake, and anthropometric correlations between autistic and typically developing adolescents"

This is to advise you that your above-refenced study underwent "Expedited" review on behalf of the UNF Institutional Review Board and has been approved under categories 4 and 7.

This approval applies to your study in the form and content as submitted to the IRB for review. Any modifications to the approved procedures or documents must be submitted to the IRB for review prior to implementation, including personnel changes. To submit an amendment to your approved protocol, please complete an Amendment Request Document and upload it along with any updated materials affected by the changes via a new package in IRBNet. For additional guidance on submitting an amendment, please contact an IRB administrator.

Please be advised that any subject complaints, unanticipated problems, or adverse events that occur are to be reported to the IRB as soon as practicable, but no later than 3 business days following the occurrence. Please use the Event Report Form to submit information about such events.

Upon completion of this study, please submit a Closing Report Form within a new package in IRBNet. Please maintain copies of all research-related materials for a minimum of 3 years following study closure. These records include the IRB-approved protocol, approval memo, questionnaires, survey instruments, consent forms, and all IRB correspondence.

Should you have questions regarding this determination, please contact the Research Integrity unit of the Office of Research and Sponsored Programs by emailing IRB@unf.edu or calling (904) 620-2455.

Appendix B

ST. PAUL'S CATHOLIC SCHOOL
428 SECOND AVENUE NORTH
JACKSONVILLE BEACH, FL 32250-5597
TELEPHONE (904) 249-5934

From: Krissy Thompson, Principal St. Paul's Catholic School

To: University of North Florida, Institutional Review Board

RE: LETTER OF SUPPORT ICO OF KRISTIN BERG FOR PARTICIPATION IN DOCTORAL STUDY

Dear UNF IRB,

On behalf of St. Paul's Catholic School, I have agreed to support student participation in the study titled "Nutrition perception, dietary intake, and anthropometric correlations between autistic and typically developing adolescents."

I will distribute study participation materials to the parents of my current students who fit the profile of the targeted study population.

Any questions concerning our consent to participate in this study, please contact me at 904-249-5934

In Christ,

Krissy Thompson

Principal

Appendix C

ASD Recruitment Form

Thank you for your interest in this autism nutrition study. Please follow the instructions below to get started.

1. Review the study information below.

2. Respond to the questions below to determine if your child is eligible to participate.

3. If your child is eligible, please complete the form including personal information.

4. Within 2-4 business days you will receive an email from the primary researcher with instructions for completion of study requirements.

Study information:
This nutrition study is being conducted by a University of North Florida doctoral candidate. The study will explore nutrition and dietary relationships between adolescents on the autism spectrum and adolescents who are not on the autism spectrum. There is limited research exploring how adolescents think about their own nutrition and dietary choices and how their food choices affect their health.

What is required from the parent or guardian?
Access to the internet for completion of a survey and a one-time virtual meeting with the researcher and your child.
An email address to send documents and links.
Complete a food questionnaire about your child.
Take body measurements of your child around their waist.
Obtain height and weight records from previous doctor visits.

What is required from the child?
Access to the internet for completion of a survey and a one-time virtual meeting with the researcher.
Answer questions about your diet.
Allow a parent or guardian to measure your waist with a paper tape measure.

How long will it take?
The one-time virtual meeting will take approximately 45 minutes.
The child survey will take approximately 10 minutes.
The parent questionnaire will take approximately 15 minutes.

Will there be any compensation?
There is no monetary compensation for participation in this study.

Who will this study benefit?
The results from this study may lead to a better insight for early nutrition needs among the ASD population.

Age of child

11

12

13

14

Other

>>

My child has been diagnosed with:

Autism Spectrum Disorder Level 1 (subjects require some support and may face social challenges)

Autism Spectrum Disorder Level 2 (subjects require substantial support where social challenges may make holding a conversation difficult)

Autism Spectrum Disorder Level 3 (subjects require very substantial support and find it very difficult to use or understand verbal and nonverbal communication)

<< >>

Child's name

Parent / guardian's name

Parent / guardian's email address

Parent / guardian's contact phone number

Child's Gender

Male

Appendix D

Informed consent

Consent Form

You and your child are invited to participate in a research study conducted by doctoral student Kristin Berg, a Registered Dietitian Nutritionist interested in examining the relationship between nutrition status and body composition in children on the autism spectrum, compared with typically developing children, ages 11 to 14.

The purpose of this study is to determine if adolescents on the autism spectrum have different nutrition perceptions, dietary intake, and body composition measurements than typically developing adolescents.

If your child voluntarily participates in this study, all communications will be sent to your email address or mailed to the home. You will be the primary point of contact for your child.

Your child will receive a form to assent to the study. This assent process will be conducted via a virtual meeting using Zoom with the Principal Investigator, Kristin Berg.

- Your child will be assessed through one survey and one questionnaire that will be discussed in the virtual meeting after assent from your child.
- Body measurements include having a paper tape measure placed around the waist by the parent for three consecutive measurements.
- Parents will also be asked to contact your child's physician for measurement

Participation in this study is voluntary and you may decide not to participate in the study at any moment. Any preferences or refusal from the child during the assessment will be honored. If you have any questions or concerns about this study, we welcome and encourage you to contact the Principal Investigator of this study via email n00100477@unf.edu or cell (904) 576-1523.

A virtual meeting can be scheduled to address any questions that may not sufficiently be answered via email. Upon request, a copy of this form will be emailed to you to keep for your records. If you have questions about your rights as the parent of a research participant or if you would like to contact someone other than the principal investigator about this research, please contact the chair of the UNF Institutional Review board by calling (904) 620-2498 or emailing irb@unf.edu.

By clicking the button at the end of this consent, you acknowledge:
Participation in the study is voluntary for you and your child. You are at least 18 years of age consenting for a minor. You are aware that you may choose to terminate your participation at any time for any reason.

>>

Child's Name

Child's home address

Parent or Caregiver's Name

Parent or caregiver's email address

Parent or caregiver's contact phone number

Child's age

- 11
- 12
- 13
- 14

Child's Gender

- Male
- Female
- Additional Comments

Child's diagnosis - please refer to the informed consent letter for descriptions of the levels.

- ASD Level 1
- ASD Level 2

Where did you receive information about this study?

- My child's school
- My child's outpatient behavioral facility
- A friend or referral
- Social Media
- Other

My child's outpatient behavioral facility

A friend or referral

Social Media

Other

Please type your name here for signature.

<< >>

Please choose one of the consent options

I consent, begin the study

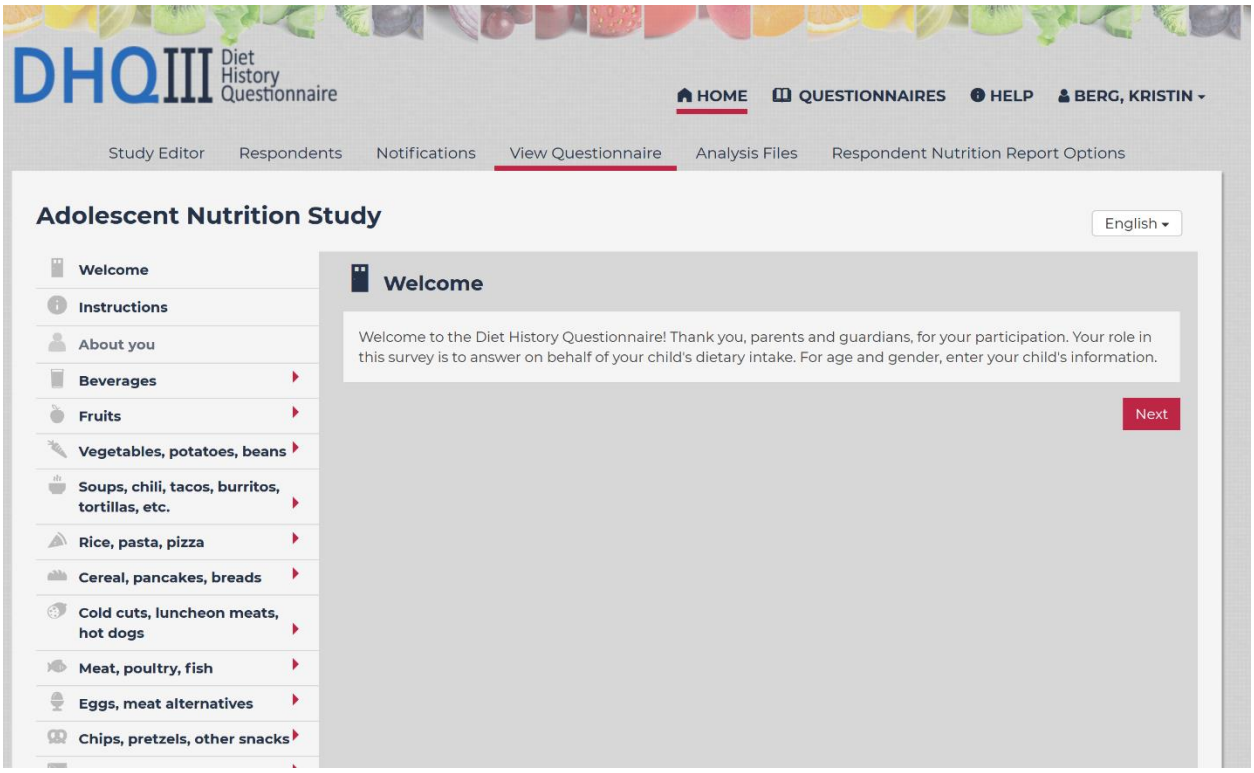
I do not consent, I do not wish to participate

<< >>

1. Please read the informed consent thoroughly.
2. Contact the Principal Investigator, Kristin Berg, with any questions about the study or consent.
3. Click one of the two options for consent.
4. Complete the questions below.
5. An email from the Principal Investigator will follow within 2-4 days after consent.

<< >>

Appendix E


DHQIII Diet History Questionnaire
HOME
QUESTIONNAIRES
HELP
BERG, KRISTIN
Study Editor
Respondents
Notifications
View Questionnaire
Analysis Files
Respondent Nutrition Report Options
Adolescent Nutrition Study
English
Welcome
Instructions
About you
Beverages
Fruits
Vegetables, potatoes, beans
Soups, chili, tacos, burritos, tortillas, etc.
Rice, pasta, pizza
Cereal, pancakes, breads
Cold cuts, luncheon meats, hot dogs
Meat, poultry, fish
Eggs, meat alternatives
Chips, pretzels, other snacks
Welcome
Welcome to the Diet History Questionnaire! Thank you, parents and guardians, for your participation. Your role in this survey is to answer on behalf of your child's dietary intake. For age and gender, enter your child's information.
Next

Appendix F

Body Measurements Survey

UNF UNIVERSITY of NORTH FLORIDA

Instructions for taking measurements.

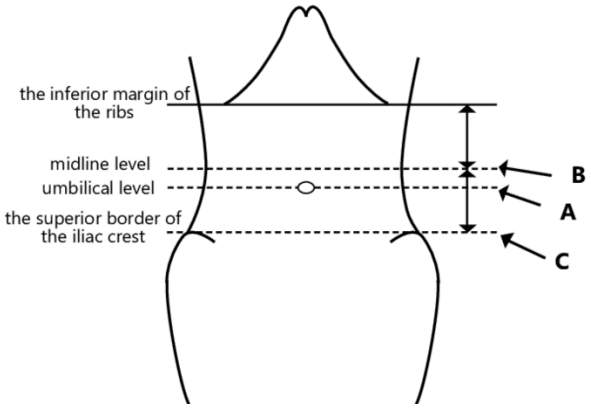
Very important information in bold. Please read the instructions thoroughly before entering information in the survey.

1. Contact your child's primary care doctor or pediatrician to ask for the last two **annual** height (**in centimeters**) and weight (**in kilograms**) measurements from their records.
2. When you receive the paper tape measure in the mail, please read and follow these instructions to properly take your child's waist measurements

***You will need the paper tape measure provided and a washable marker.**

****Please note the paper tape has extra length that can be folded back or cut on the black line before the beginning of the tape or the "1".**

1. **Gather the child's shirt to just above the waist.**
2. **Ask your child to gently hug their shoulders.**
3. **Locate the lowest rib on their LEFT side and mark the bottom of the rib with a small line.**
4. **Locates the top of the LEFT hip bone on the side and marks the top of the hip bone with a small line.**
5. **Using the tape measure, measure the distance from one line to the other and find the middle of the distance. This is the waist.**
6. **Repeat steps 1 through 5 on the RIGHT side.**
7. **Place the measuring tape at the mark and wrap around the waist.**
8. **When the child releases a regular breath, take the measurement using the CENTIMETERS side of the tape.**
9. **Write down the measurement to the nearest half (.5) centimeter.**
10. **Repeat steps 7 through 9 two more times for a total of three measurements and enter them in the survey. *Use the link provided in the "Body Measurements for Nutrition Study" email.**



Please enter your child's full name.

Year 1 Height in centimeters

Year 1 Weight in kilograms

Year 2 Height in centimeters

Year 2 Weight in kilograms

Measurement 1 - Waist circumference in centimeters.

Measurement 2 - Waist circumference in centimeters.

Measurement 3 - Waist circumference in centimeters.

Appendix G

Anthropometric Measurements

- Weight will be self-reported by the parent or guardian of subject. A parent or guardian will obtain from their child's physician the two most recent and consecutive weight measurements from their annual well-visits.
- Height will be self-reported by the parent or guardian of subject. Parent or guardian will obtain from their child's physician the two most recent and consecutive height measurements from their annual well-visits.
- Body mass index (BMI) can be obtained from measured weight and height. Height in centimeters will be converted to meters. Equation for BMI: weight (kg) / [height (m)]^2.
- Waist circumference

  Parent Instructions

  ***You will need the paper tape measure provided and a washable marker.**
  ****Please note the paper tape has extra length that can be folded back or cut on the black line before the beginning of the tape or the "1".**

  1. **Gather the child's shirt to just above the waist.**
  2. **Ask your child to gently hug their shoulders.**
  3. **Locate the lowest rib on their LEFT side and mark the bottom of the rib with a small line.**
  4. **Locates the top of the LEFT hip bone on the side and marks the top of the hip bone with a small line.**
  5. **Using the tape measure, measure the distance from one line to the other and find the middle of the distance. This is the waist.**
  6. **Repeat steps 1 through 5 on the RIGHT side.**
  7. **Place the measuring tape at the mark and wrap around the waist.**
  8. **When the child releases a regular breath, take the measurement using the CENTIMETERS side of the tape.**
  9. **Write down the measurement to the nearest half (.5) centimeter.**
  10. **Repeat steps 7 through 9 two more times for a total of three measurements and enter them in the survey. *Use the link provided in the "Body Measurements for Nutrition Study" email.**

Appendix H

Assent Form

The researchers are interested in understanding how children your age think about food and diet. For this study, you will be presented with information relevant to nutrition and body measurements.

The purpose of this study is to determine if adolescents on the autism spectrum have different nutrition perceptions, dietary intake, and body composition measurements than typically developing adolescents.

You may benefit from this study by being more aware of your diet and learn more about the research process. In addition, others may benefit from what we learn about the results of this study.

The risks involved in participating in this study are minimal and no greater than those associated with normal daily activities. Participation in this study encouraged, and you are free to decide if you will participate. Any preferences or refusal from you during the assessment will be honored.

What is expected from you?

- You will complete a questionnaire about the kinds of foods you like to eat and what you think about the foods you eat.
- You will also complete a questionnaire that takes a list of all the foods you ate in the last 24 hours from that day you enter the information.
- You will also have your waist circumference measured by your parent. You will be mailed a paper tape measure and you parent will wrap it around your waist three times in a row, after they find the exact place on your sides between your hips and ribs.

All of your responses will be kept private.

The questionnaires should take around 30 minutes to complete and you may need your parent to help you complete the questionnaires. The waist measurements should take about 10 minutes.

You are a volunteer for this research. You have the right to withdraw at any point during the study. If your object to physical touch by a parent, you should not consider participating in this study.

The Principal Investigator of this study, Kristin Berg, can be contacted via email at her University of North Florida email address, n00100477@unf.edu. Thank you for your consideration.

A copy of this form will be emailed to you to keep for your records.

If you have questions about your rights as a research participant or if you would like to contact someone about a research-related injury, please contact the chair of the UNF Institutional Review board by calling (904) 620-2498 or emailing irb@unf.edu. Thank you for your consideration.

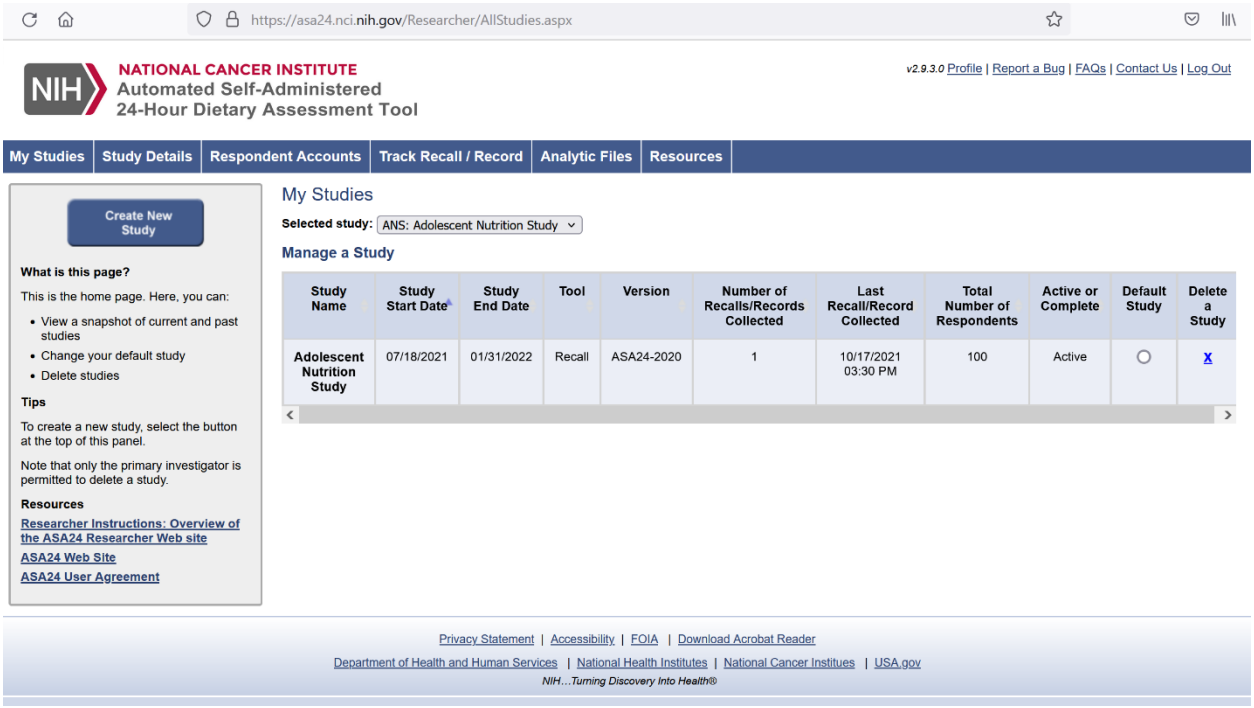
By clicking the button below, you acknowledge:

- Your participation in the study is voluntary.
- You are aware that you may choose to terminate your participation at any time for any reason.

I assent, begin the study

I do not assent to this study, I do not wish to participate

Appendix I


https://asa24.nci.nih.gov/Researcher/AllStudies.aspx
NIH
NATIONAL CANCER INSTITUTE
Automated Self-Administered
24-Hour Dietary Assessment Tool
v2.9.3.0 Profile | Report a Bug | FAQs | Contact Us | Log Out
My Studies
Study Details
Respondent Accounts
Track Recall / Record
Analytic Files
Resources
Create New Study
What is this page?
This is the home page. Here, you can:
• View a snapshot of current and past studies
• Change your default study
• Delete studies
Tips
To create a new study, select the button at the top of this panel.
Note that only the primary investigator is permitted to delete a study.
Resources
Researcher Instructions: Overview of the ASA24 Researcher Web site
ASA24 Web Site
ASA24 User Agreement
My Studies
Selected study: ANS: Adolescent Nutrition Study
Manage a Study
Study Name
Study Start Date
Study End Date
Tool
Version
Number of Recalls/Records Collected
Last Recall/Record Collected
Total Number of Respondents
Active or Complete
Default Study
Delete a Study
Adolescent Nutrition Study
07/18/2021
01/31/2022
Recall
ASA24-2020
1
10/17/2021 03:30 PM
100
Active
X
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Appendix J

Questions included for item selection

Habits	
How Often Do You Eat Your Main Meal Away From Home?	0 'Never or up to once per month' 1 'Two to three times per month' 2 'Once per week' 3 'Twice or more per week'
How Often Do You Prepare A Meal "From Scratch"?	0 'Every day' 1 '4-6 times per week' 2 '1-3 times per week' 3 '(Almost) never'
How Many Hot Or Cooked Meals Do You Normally Eat Per Day?	0 'Never or rarely eat hot or cooked meals' 1 'One' 2 'Two' 3 'Three or more'
What Factor Do You Consider The Most Relevant When Selecting A Recipe?	0 'Preparation time' 1 'Number of ingredients' 2 'Complexity'
How Much Time On Average Do You Spend Preparing A Main Meal?	0 'Less than 10 minutes' 1 '10-20 minutes' 2 '20-30 minutes' 3 'Up to an hour' 4 'Over an hour'
Do You Skip Meals And Replace Them With Snacks?	0 'Every day' 1 '4-6 times per week' 2 '1-3 times per week' 3 '(almost) never'
In The Past Month, How Often Did You Eat Fried Food?	0 'One per day' 1 '5-6 per day' 2'2-4 per week' 3 'One a week' 4 '1-3 per month' 5 'Never'
Health perception – Health Locus of Control	
I Can Be As Healthy As I Want To Be	
I Am In Control Of My Health	0 'Completely disagree' 1 'Disagree' 2 'Neither disagree nor agree' 3 'Agree' 4 'Completely agree'
I Can Pretty Much Stay Healthy By Taking Care Of Myself	
Efforts To Improve Your Health Are A Waste Of Time	
I Am Bored By All The Attention That Is Paid To Health And Disease Prevention	
What's The Use Of Concerning Yourself About Your Health - You'll Only Worry Yourself To Death	
Eating perception – Self-Report Habits Index	
Eating Healthily Is Something I Do Frequently	0 'Completely disagree' 1 'Disagree' 2 'Neither disagree nor agree' 3 'Agree' 4 'Completely agree'
I Eat Healthily Without Having To Consciously Think About It	
I Feel Weird If I Don't Eat Healthily	
Eating Healthily Is Something I Don't Have To Think About Doing	
Healthy eating management – Nutrition Self-Efficacy	
I Can Manage To Stick To Healthful Foods:	
Even If I Need A Long Time To Develop The Necessary Routines	0 'Very uncertain' 1 'Rather uncertain' 2 'Rather certain' 3 'Very certain'
Even If I Have To Try Several Times Until It Works	
Even If I Have To Rethink My Entire Way Of Nutrition	
Even If I Do Not Receive A Great Deal Of Support From Others When Making My First Attempts	
Even If I Have To Make A Detailed Plan	

Appendix K

Supplemental Tables from SPSS analyses.

Table 4-4. Comparisons between ASD Levels for Child-Reported HEI score, Individual Nutrients/Food Categories, Nutrition Perception, Body Measures.[1]

Dietary Intake Variables	n	Mean	SD		n	Mean	SD	P value
	ASD Level 1				ASD Level 2			
Kilocalories[2]	17	2623.37	927.21		2	3911.19	2363.88	**.062**
Protein[2]	17	96.97	35.79		2	130.71	43.50	.230
Carbohydrates[2]	17	310.66	128.71		2	466.69	348.10	.092
Total Fat[2]	17	114.43	48.64		2	169.46	92.87	.089
Total Dairy[2]	17	2.29	1.50		2	4.69	3.31	**.035**
Total Fruits[2]	17	0.82	0.80		2	0.31	0.44	.200
Total Vegetables[2]	17	2.44	1.33		2	1.56	2.20	.206
Whole Grains[2]	17	0.85	1.23		2	1.65	2.33	.213
Added Sugars[2]	17	18.96	17.54		2	25.40	31.96	.325
Animal Protein[2]	17	5.63	4.08		2	4.00	2.73	.297
Plant Protein[2]	17	0.89	1.34		2	0.24	0.34	.255
Total HEI[2]	17	54.18	11.42		2	41.45	12.41	**.078**
Nutrition Perception Total	17	54.29	7.83		2	54.50	10.61	.487
NP Dietary Habits	17	13.12	2.55		2	12.50	2.12	.374
NP Health Perception	17	18.71	3.04		2	19.00	4.24	.451
NP Eating Perception	17	12.06	3.34		2	13.00	4.24	.358
NP Healthy Eating Management	17	10.41	2.40		2	10.00	0.00	.408
Mean Waist Circumference	17	75.59	7.95		2	79.00	28.99	.334
BMI	17	21.43	3.99		2	22.76	12.89	.361
Waist-to-Height Ratio	17	46.24	5.69		2	46.79	9.89	.452

1. Values are mean (95% confidence interval)
2. Healthy Eating Index variables from child-reported ASA-24 survey

Independent sample t-tests compared the mean value differences between the two ASD groups (Level 1 and Level 2) (Table 4-4). There was a significant difference between ASD Level 1 and Level 2 for Total dairy (P=0.035) intake, and a moderate difference between both groups for kilocalories (P=0.062) and Total HEI (P=0.078).

Table 4-5. Comparisons between ASD Age Groups for Child-Reported HEI score, Individual Nutrients/Food Categories, Nutrition Perception, Body Measures.[1]

Dietary Intake Variables	n	Mean	SD		n	Mean	SD	P value
	ASD Age Group 1 (11-13)				ASD Age Group 2 (14-17)			
Kilocalories[2]	7	2357.82	739.72		12	2992.82	739.72	.120
Protein[2]	7	86.55	20.06		12	108.67	42.47	.108
Carbohydrates[2]	7	313.28	115.29		12	335.13	177.84	.386
Total Fat[2]	7	86.30	34.31		12	140.01	53.99	**.015**
Total Dairy[2]	7	2.57	0.09		12	2.52	2.18	.476
Total Fruits[2]	7	1.01	0.81		12	0.62	0.75	.149
Total Vegetables[2]	7	2.13	1.80		12	2.47	1.15	.308
Whole Grains[2]	7	1.00	.089		12	1.17	1.43	.436
Added Sugars[2]	7	18.29	15.44		12	20.41	20.37	.408
Animal Protein[2]	7	4.05	2.24		12	6.28	4.53	.123
Plant Protein[2]	7	0.52	0.91		12	1.00	1.46	.226
Total HEI[2]	7	53.01	10.46		12	52.74	13.05	.482
Nutrition Perception Total	7	55.00	8.02		12	53.92	8.00	.390
NP Dietary Habits	7	14.00	22.34		12	12.50	2.51	.104
NP Health Perception	7	17.86	2.61		12	19.25	3.25	.174
NP Eating Perception	7	12.71	2.50		12	11.83	3.79	.296
NP Healthy Eating Management	7	10.43	2.15		12	10.33	2.43	.466
Mean Waist Circumference	7	73.12	12.57		12	77.60	8.72	.185
BMI	7	20.79	5.27		12	22.03	4.78	.306
Waist-to-Height Ratio	7	48.13	8.21		12	45.22	3.97	.154

1. Values are mean (95% confidence interval)
2. Healthy Eating Index variables from child-reported ASA-24 survey

Independent sample t-tests compared the mean value differences for the child-reported HEI score and individual nutrients/food variables, nutrition perception variables, and body measures variables (Table 4-5) between the two ASD age groups (Group 1 and Group 2). There was a significant difference between ASD age group 1 and age group 2 for total fat (P=0.015) intake.

Table 4-6. Comparisons between TD age groups for child-reported HEI score, individual nutrients/food categories, nutrition perception, body measures.[1]

Dietary Intake Variables	n	Mean	SD		n	Mean	SD	P value
	TD Age Group 1 (11-13)				TD Age Group 2 (14-17)			
Kilocalories[2]	6	2114.72	619.69		17	2876.03	1253.98	.086
Protein[2]	6	89.98	36.90		17	109.30	48.78	.194
Carbohydrates[2]	6	232.80	90.06		17	324.23	165.90	.109
Total Fat[2]	6	94.12	23.91		17	129.12	57.19	.083
Total Dairy[2]	6	1.17	0.67		17	2.09	1.95	.137
Total Fruits[2]	6	1.21	1.24		17	.060	.084	.095
Total Vegetables[2]	6	1.72	.038		17	2.10	1.22	.233
Whole Grains[2]	6	.033	.080		17	.039	.072	.429
Added Sugars[2]	6	11.07	7.50		17	21.26	19.16	.112
Animal Protein[2]	6	4.62	3.30		17	6.25	3.88	.186
Plant Protein[2]	6	1.90	2.09		17	.055	1.09	**.027**
Total HEI [2]	6	47.56	12.35		17	47.10	10.67	.466
Nutrition Perception Total	6	48.00	4.86		17	48.39	6.25	.446
NP Dietary Habits	6	13.67	3.32		17	10.11	2.35	**.004**
NP Health Perception	6	16.83	1.72		17	18.67	2.68	.067
NP Eating Perception	6	9.00	2.37		17	9.89	2.54	.230
NP Healthy Eating Management	6	8.50	3.73		17	9.78	1.66	.126
Mean Waist Circumference	6	68.94	7.42		17	72.15	13.68	.297
BMI	6	19.05	2.86		17	21.36	2.84	**.049**
Waist-to-Height Ratio	6	44.28	4.40		17	41.98	7.59	.246

1. Values are mean (95% confidence interval)
2. Healthy Eating Index variables from child-reported ASA-24 survey

Independent sample t-tests compared the mean value differences for the child-reported HEI score and individual nutrients/food variables, nutrition perception variables, and body measure variables (Table 4-6) between the two TD age groups (Group 1 and Group 2). There was a significant difference between TD age group 1 and age group 2 for plant protein (P=0.027) intake, nutrition perception dietary habits (P=0.004), and BMI (P=0.049).

Table 4-6. Differences of ASD child-reported HEI variable means with National Means.[1]

Variable Correlation	ASD HEI Means[2]	National HEI Means[3]	*P* value
HEI Total Fruits[2]	1.85	3.7	.176
HEI Whole fruits[2]	1.34	4.9	**.043**
HEI Total Vegetables[2]	3.70	2.2	.174
HEI Greens and Beans[2]	2.01	1.6	.431
HEI Whole Grains[2]	2.08	3.0	.376
HEI Dairy[2]	6.40	7.4	.391
HEI Total Protein Foods[2]	4.06	4.7	.296
HEI Seafood and Plant Proteins[2]	1.65	3.1	.268
HEI Fatty Acids[2]	5.69	3.2	.247
HEI Refined Grains[2]	5.52	4.6	.369
HEI Sodium[2]	4.11	5.1	.389
HEI Added Sugars[2]	9.11	6.2	**.023**
HEI Saturated Fats[2]	4.03	4.7	.432

1. Values are mean (95% confidence interval)
2. Healthy Eating Index variables from child-reported ASA-24 survey (pearson-*r* correlates with significant *p* values)
3. Average Healthy Eating Index-2015 Scores for All Americans by Age Groups, WWEIA, NHANES 2017-2018[123]

Independent sample t-test compared the mean values of the child-reported HEI food categories with HEI food category national averages referenced from NHANES 2017-2018. Significant differences are found between the study sample means and national averages for HEI whole fruits (p=0.043) and HEI added sugars (p=0.023).