DISSERTATION

FOOD SELECTIVITY AND WEIGHT STATUS IN CHILDREN WITH AN AUTISM SPECTRUM DISORDER (ASD)

Submitted by

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ABSTRACT

FOOD SELECTIVITY AND WEIGHT STATUS IN CHILDREN WITH AN AUTISM SPECTRUM DISORDER (ASD)

Today, Autism Spectrum Disorders (ASD) have been reported to affect one in 68 children in the United States and one in 42 boys (CDC, 2014); boys are five times more likely to be diagnosed with an ASD when compared to girls (Autism Speaks, 2012). ASD is characterized by core deficits in social interactions, speech, repetitive behaviors and restricted interests, and individuals with an ASD experience varying degrees of impairments (Croen et al., 2002).

Dietary intake in children with an ASD appears to differ from typically developing children (Cornish, 1998; Schreck et al., 2004; Lockner et al., 2008; Eaves and Ho, 2008; Herndon et al., 2009). Even though dietary intake appears to differ between children with an ASD compared to typically developing children, the research has reported conflicting results (Zimmer and Hart, 2012).

Childhood obesity is a serious health issue in the United States; but despite the growing evidence of obesity in children, there is minimal research that has examined this problem in children with developmental disorders, especially children with an ASD. There is a small amount of evidence suggesting that children with an ASD may be at a greater risk of obesity when compared to typically developing children. It has been hypothesized that this may be due to the limited variety and consumption of fruits, vegetables, lean meats and low-fat dairy products that children with an ASD consume (Curtin C, 2010, 2005).

There are numerous case reports and considerable anecdotal evidence that supports food selectivity in children with an ASD is a problem, but there is limited empirical evidence (Levin et al., 2001). Furthermore, food selectivity was not operationally defined until 2010 by Bandini and colleagues; therefore, food selectivity was not consistently measured prior to 2010. Recently, food selectivity was operationalized by defining it into three domains: food refusal, limited food repertoire, and high single food intake (Bandini et al., 2010). However, it remains unclear if there is a pattern to the unusual intake and how it may affect nutritional and weight status in children who are considered to be food selective.

The overall objectives of this study are first to investigate nutrient adequacy of diets of children with an ASD and compare them to age-matched children with other developmental disabilities also referred to as neuro-impaired comparison (NIC) in this study and to children who are typically developing (TD) ; and second to examine the relationship of food selectivity to nutritional and weight status in three groups of children ages two to six years old: (1) those with an ASD; (2) a comparison group with other developmental disorders; and (3) typically developing children.

This study was a cross-sectional case control study. This study analyzed data that were collected for the Study to Explore Early Development (SEED) which was a collaborative epidemiologic study to identify risk factors for autism. Three day food records were completed for all participants and are frequently used in research and clinical practice. Weight and height measurements were used to calculate Body Mass Index. Analyses were based on three day food records, height and weight measurements, and participant information.

An analysis of data assessed nutrient intakes across the three comparison groups (ASD, NIC, TD) and whether food selectivity is related to nutrient intake and weight status. To better understand the sample of participants, descriptive statistics (frequencies, percentages, means, and standard deviations) were run on the demographic variables of interest. In addition, Chi-square tests were conducted in order to determine if there was a statistical difference among the demographic variables. Means were corrected for child sex, age of child, maternal ethnicity, maternal level of education, maternal income, and total kilocalories consumed. For each hypothesis, descriptive statistics were conducted (mean, median, standard deviations) in order to gain a better understanding of the variables of interest and prior to formal analysis. Limited food repertoire ($\leq$ 22 food items consumed over a three day period) and high frequency single food intake (HFSFI; single foods eaten $\geq$ 4 times daily) will be assessed to determine if a participant is food selective. If a participant was considered to have a limited food repertoire or HFSFI, then they will be classified as food selective. The adequacy of nutritional intake was determined by comparing mean dietary intakes to the Estimated Average Requirements (EAR) or an Adequate Intake (AI; IOM, 2000). One-way analyses of covariance (ANCOVA) were done to determine the differences among the groups. In order to test the hypotheses regarding weight status, BMIz scores, BMI mean percentiles, standard deviations, and one-way ANCOVA's were calculated for the participants. One-way analyses of covariance (ANCOVA) tests were used to examine the differences among the groups in regards to the hypotheses and logistic transformations were done for high frequency single food intake and food selectivity since they were binary outcomes (yes or no).

The results indicated that there were few significant differences in mean intakes of macro- and micronutrients among the three groups (ASD, NIC, TD). Contrary to hypothesis 3 and 4, there were no significant differences of prevalence of overweight and obesity in the ASD group ($p>.05$); moreover there were no significant differences in growth faltering ($\leq$ 5th %tile) among the groups. The results also illustrated that the ASD group were significantly more food selective (46%) when compared to NIC (31%) and TD (26%). Contrary to our prediction, children with an ASD who were food selective did not appear to be at an increased risk of becoming overweight and/or obese. Previous literature and our results demonstrated that children with an ASD, who are food selective, preferred energy dense foods which may contribute to the development of overweight and/or obesity over a period of time. Greater detail and more research is needed to better understand the correlation between BMI status, dietary intake and food selectivity in children with an ASD.

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DEDICATION

TO MY PARENTS

Thomas Atkins Withrow

Janet Irvin Withrow

TO MY SISTERS

Kristen Lynn Withrow

Cynthia Lee Withrow

TO MY BROTHER-IN-LAW

William Scott Boatman

TO MY HUSBAND

Riddell Matthew McDonald

TO MY CHILDREN

Madelynn Jane McDonald

Samuel Atkins McDonald

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Chapter 1

Introduction

Today, Autism Spectrum Disorders (ASD) have been reported to affect one in 68 children in the United States and one in 42 boys (CDC, 2014); boys are five times more likely to be diagnosed with an ASD when compared to girls (Autism Speaks, 2012). Children can be reliably diagnosed with an ASD between two and three years of age by an experienced clinician(s) (Stone et al., 1999). The criterion for an ASD diagnosis is based on The Diagnostic and Statistical Manual 5 (DSM-5) for mental health disorders. Autism Spectrum Disorders are the fastest growing and long-term developmental disability in the United States (Autism Speaks, 2012). ASD is characterized by core deficits in social interactions, speech, repetitive behaviors and restricted interests, and individuals with an ASD experience varying degrees of impairments (Croen et al., 2002). Children with an ASD may have a difficult time understanding how to initiate a conversation, respond to joint attention with peers, and they may struggle in maintaining communication (Newschaffer et al., 2007). Some children with an ASD may also have impairments in understanding non-verbal communication such as gesturing, following a person's eye gaze, intentions to communicate and difficulty expressing their feelings appropriately. Along with the social impairments, children with an ASD may have co-occurring diagnoses such as learning disabilities, heightened generalized anxiety, sleep disturbances, gastrointestinal problems, problematic eating behaviors and obsessive compulsive disorders (Johnson et al., 2007).

Feeding problems are defined as limitations to the intake of adequate nutrition and can occur because of structural abnormalities, neurological conditions, behavioral problems, cardiorespiratory problems, metabolic dysfunction (Burklow 1998), sensory sensitivities (Schwarz, 2003), and oral and fine motor impairments (Amato, 1998; Green, 2002; Field and Garland, 2003). Feeding problems can be complex and are often multi-factorial which can impact a child's health and well-being. Feeding problems are common in childhood, they are reported to occur in 25% to 35% of typically developing children (Burklow et al., 1998) and in 46% to 89% of children with an ASD (Cornish, 1998; Ahearn et al., 2001; Bowers, 2002; Cornish, 2002; Field and Garland, 2003; Schreck et al., 2004). Feeding problems for children with an ASD include food refusal, food selectivity, rituals related to food and mealtime, sensory aversions and defiant behaviors (Williams et al., 2000). Sensory processing impairments are often discussed in conjunction with food selectivity and food refusal in children with an ASD.

Dietary intake in children with an ASD appears to differ from typically developing children (Cornish, 1998; Schreck et al., 2004; Lockner et al., 2008; Eaves and Ho, 2008; Herndon et al., 2009). Even though dietary intake appears to differ between children with an ASD compared to typically developing children the research has reported conflicting results (Zimmer and Hart, 2012).

Levin and researchers characterized food selectivity as a diet that is limited in a variety of food items, and that individuals reject novel foods when offered (Levin et al., 2001). Although picky eating is not uncommon in young children, it appears that children with an ASD may be more selective and it may extend past childhood. There are numerous case reports and considerable anecdotal evidence that supports that food selectivity in children with an ASD is a problem, but there is limited empirical evidence (Monks, 2002; Steinemen & Christiansen, 1998). Furthermore, food selectivity was not operationally defined until 2010 by Bandini and colleagues; therefore, food selectivity was not consistently measured and defined prior to 2010 (Bandini et al., 2010). These unusual eating habits can interfere with the child's ability to consume adequate amount and variety of foods necessary for healthy growth and development. It has been suggested that there are implications for nutrient insufficiency in children with ASD compared to typically developing children (Herndon et al., 2009; Cornish, 1998; Schreck et al., 2004).

It is well known that obesity has dramatically increased over the past 20 years and is considered an "epidemic" and a "public health crisis" and can affect all children (Ogden et al., 2014, 2008). The prevalence of childhood obesity has tripled over the past two decades and has been estimated to affect approximately 8.4%-20.5% of U.S. children, ages two to nineteen years, and the prevalence of overweight in children is approximately 34.5% (Ogden et al., 2014). It appears that 29% of White girls are overweight/obese compared to 36% of African American and 37% in Hispanic girls (Ogden et al., 2014). Approximately, 40% of Hispanic boys are overweight/obese compared to 34% of African American and 28% of White boys (Ogden et al., 2014). According to Curtin and colleagues, the prevalence of obesity in children with an ASD was 30.4% compared to 24% in typically developing children (Curtin et al., 2010). Childhood obesity is a serious health issue in the United States, but despite the growing evidence of obesity in children, there is minimal research that has examined this problem in children with developmental disorders, especially children with an ASD. There is a small amount of evidence suggesting that children with an ASD may be at a greater risk of obesity when compared to typically developing children (Curtin et al., 2005). It has been hypothesized that this may be due to the limited variety and consumption of fruits, vegetables, lean meats and low-fat dairy products that children with an ASD consume (Curtin C, 2010, 2005).

It is not well understood how food selectivity impacts nutritional and weight status in children with an ASD. The few studies that exist concentrate on dietary intake and weight status in children with an ASD, but have not investigated the relationship of food selectivity while comparing it to dietary intake, and weight status in children with an Autism Spectrum Disorder (ASD). In addition other developmental disorders/neuro-impaired (NIC) or typically developing (TD) children have not been thoroughly investigated.

The proposed study will examine the relationship of food selectivity and weight status among the three groups (ASD, NIC, TD), children ages two to six years old, using existing Study to Explore Early Development (SEED) data. The overall objectives of this study are: 1) to investigate nutrient adequacy of diets of children with an ASD and compare them to age matched children who are typically developing (TD) and to children with other developmental disabilities (NIC); and 2) to examine the relationship of food selectivity to nutritional and weight status in three groups of children ages two through six years old.

Chapter 2

Literature Review

Overview of dissertation

The overall purpose of this study is to examine the relationship of food selectivity and weight status in children with an Autism Spectrum Disorder (ASD), other developmental disorders (NIC) and typically developing (TD) children, ages two through six years old, using existing Study to Explore Early Development (SEED) data. Recently, food selectivity was operationalized by defining it into three domains: food refusal, limited food repertoire, and high single food intake (Bandini et al., 2010). However, it remains unclear if there is a pattern to the unusual intake and how it may affect nutritional and weight status in children who are considered to be food selective. It is hypothesized that children with an ASD will more likely be food selective and have patterns of intake unique to their food selectivity which may impact their weight and growth status. Additionally, this study will provide a comprehensive estimation of obesity prevalence in the case and control groups exhibiting or not having food selectivity.

Literature review

This literature review will begin by defining Autism Spectrum Disorder (ASD) and other developmental disorders such as Asperger's Syndrome, Pervasive Development Disorder Not Otherwise Specified (PDD-NOS), Childhood Disintegrative Disorder, and Rett Syndrome. An overview of the prevalence of ASDs, diagnostic procedures, treatments, nutritional concerns, and secondary diagnoses will be defined. It will describe typical eating development and discuss why children with an ASD may be at increased nutritional risk. This section will end with a discussion of the importance of this study.

Literature search strategy

The databases CINAHL, MEDLINE, and PsychINFO, Web of Science, all available through OVID, were used to review the current literature on autism spectrum disorders in children and the secondary diagnoses associated with an ASD, food selectivity and weight status in children with an ASD. A comprehensive literature search began in August 2009 and continued through December 2012. The databases chosen were due to their extensive medical, neurodevelopmental, obesity, and dietary journals.

The evolution of discovering Autism

In the early 1940s, Leo Kanner, a psychiatrist from Johns Hopkins, defined autism as a syndrome (Kanner,1944). Kanner stated that most individuals experience atypical behavior beginning in infancy, suggesting that children with autism suffer with repetitive, restricted, and stereotyped patterns of behavior, along with impaired social interactions, verbal and nonverbal communication (Volkert and Vaz*,* 2010). He discussed that autism was likely to be rare and often confused with schizophrenia. Kanner stated that symptoms included: abnormal speech with echolalia, pronominal reversal, inability to use language in a communicative way, monotone when speaking, and the extreme need for sameness (Frith, 2008). Kanner reported that males seem to be affected more often than females and are born into this world with the “innate inability to form the usual biologically provided affective contact with people (Klintwall et al., 2011; Yang et al., 2011). Kanner also studied the parents of children with autism and described the parents as highly intelligent, preoccupied with abstractions of a scientific, literary or artistic nature and who appear to have a limited interest in people which may suggest a genetic causation.

In the 1950s, autism was being reported more often, and during the next three decades the definition of autism expanded. The predominant view in the 1960s was that the origins of autism were environmentally based rather than biological (Frith, 2008). Some researchers in the 1960s reported that a genetic basis to autism was not feasible since the disorder did not run in families, and that it was not common to have more than one child with autism in a given family. Parent and child interactions were observed by experienced clinicians, and they suggested that the parents and affected child did not bond adequately which later had social consequences. In 1975, the U.S. Developmental Disability Act included individuals with autism because of their long-term needs for continuous financial support and the need for special educational services (Frith, 2008).

Today, Autism is considered a spectrum disorder and, based on the DSM 5 and ICD diagnostics manuals, there are severities within the autism spectrum disorder, but that Asperger's and PDD-NOS are no longer separate diagnoses. Autism and ASD will both be used interchangeably throughout this paper.

Current Definition of Autism Spectrum Disorder (ASD)

Autism is a complex neurodevelopmental disorder that typically lasts throughout an individual's life. Today, Autism is considered a spectrum disorder and, based on the DSM 5 /ICD diagnostics manuals; there are severities within the autism spectrum disorder. Asperger's and PDD-NOS are no longer separate diagnoses as of the current

DSM-5 manual. The autism spectrum disorder (ASD) is considered a single umbrella disorder which includes: (1) childhood autism, which is considered the classic group of children previously described by Kanner in the 1940s; (2) Asperger Syndrome in which IQ is greater than 70, language development is not delayed, and social impairments appear to be less severe; (3) Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) or atypical autism which lacks an operational definition thus making it problematic to classify and study; and (4) Childhood disintegrative disorder which presents as a late-onset of autism symptoms and cognitive regression. Symptoms often include language regression, motor regression, loss of bowel and bladder use, and more often than not symptoms present after the age of three. Prior to the recent DSM 5 revisions, Rett Syndrome was considered a spectrum disorder. Today, it is a separate neurodevelopmental disorder and is not part of the single umbrella of an ASD. Autism and ASD will be used interchangeably throughout this paper.

ASD is diagnosed in all racial, ethnic, socioeconomic, and social groups. It is five times more likely to affect boys than girls (CDC, 2014). The etiology of an ASD is still unknown, which reflects the complexity of the disorder and a relative lack of research. While the cause of ASD remains unclear, ASD is considered a multifactorial disorder that can be influenced by genetic, environmental and immunological factors (Chauhan, et al., 2006). Some researchers have stated that an ASD is caused by an attack on the immune system (Castellani et al., 2009), while others believe it is caused by environmental factors (Windham et al., 2006). ASD is characterized by core deficits in social interactions, speech, repetitive behaviors and restricted interests, and individuals with an ASD experience varying degrees of impairments (Croen et al., 2002). Children with an ASD may have a difficult time understanding how to initiate a conversation, respond to joint attention with peers, and they may struggle in maintaining communication (Newschafferet al., 2007). Some children with ASD may also have impairments in understanding non-verbal communication such as gesturing, following a person's eye gaze, intentions to communicate, and difficulty expressing their feelings appropriately. Along with the social impairments, children with an ASD may have co-occurring diagnoses such as: learning disabilities, heightened generalized anxiety, sleep disturbances, gastrointestinal problems, problematic eating behaviors, and obsessive compulsive disorders (Johnsonet al., 2007).

The current DSM criteria states that an individual must exhibit symptoms within the three core domains: (1) deficits in social-emotional reciprocity ranging from abnormal social approach to reduced sharing of interests, emotions, or affect; (2) deficits in nonverbal communicative behaviors used for social interactions: ranging from poorly integrated verbal and nonverbal communication to abnormalities in eye contact, body language or deficits in gestures; (3) deficits in developing, maintaining, and understanding relationships: ranging from difficulties adjusting behavior to fit various social contexts to difficulties in sharing imaginative play or making friends. Severity of an ASD is based on social communication impairments and restricted, repetitive patterns of behavior. Individuals can now be categorized into three levels of severity. For example, Level 3 states that an individual requires "very substantial support"; Level 2 states that an individual requires "substantial support," and Level 1 states that an individual requires "support." Levels of severity can be used at the time of diagnosis to assist in treatment approaches. Symptoms of an ASD must be present in the early developmental period but may not be diagnosed until later in life (DSM-5 2013; DSM-IV-TR 2000; DSM-IV 1994). Even though the ASD is now considered a single umbrella disorder it is still important to understand Asperger's Syndrome, PDD-NOS, CDD since they are considered an ASD.

Definition of Asperger's Syndrome

In 1944 Hans Asperger, a Viennese pediatrician studied four children with similar autism traits described by Kanner. Asperger's work was similar to Kanner's and occurred during the same time period. However, Asperger described the four children he studied as having extraordinary gifts in mathematics or natural science and who had creative, original modes of thinking along with objective self-appraisal. However, the children he observed were similar to those Kanner observed such that the four children appeared to have impaired social skills and emotional relationships (Mayes et al., 2011) along with sometimes exhibiting maladaptive behaviors. During his observations, he witnessed that language use was idiosyncratic, but that language acquisition did not appear delayed, which is a characteristic of an ASD. Asperger also noticed that the parents had similar personality traits, and stated that these may be an extreme variant of male intelligence (Mayes et al., 2011). Uta Firth re-introduced Asperger's work in 1981 which led to the classification of Asperger syndrome. Named after Hans Asperger, the disorder was then included in the DSM-IV and was considered qualitatively distinct from an ASD (Sanders, 2009). Asperger's Disorder is diagnosed using the same diagnostic assessments as Autism Spectrum Disorder and is treated similarly.

Definition of Pervasive Development Disorder Not Otherwise Specified (PDD-NOS)

The DSM IV-TR, uses Pervasive Developmental Disorder (PDD) to categorize children with qualitative impairments in three behaviorally defined domains: reciprocal social interactions, verbal and nonverbal communication, and restricted and repetitive interests. The current definition and diagnostic criteria for PDD-NOS are vague and are not typically agreed upon in the medical profession. PDD-NOS is the most frequently diagnosed condition of the autism spectrum disorder'; however, it is the least well-characterized condition. PDD-NOS is often used when there is a severe and pervasive impairment in the development of reciprocal social interaction associated with verbal or nonverbal communication skills or an individual with stereotypic behaviors, interests, and activities but the criteria for another PDD is not fully met (Witwer and Lecavalier, 2008). In the DSM-IV, it did not have defined guidelines for diagnosing PDD-NOS;; it was not clear how many symptoms an individual must suffer in order to receive a diagnosis of PDD-NOS instead of Autism Spectrum Disorder (Snow et al., 2011); therefore, it is more subjective and of the clinician's opinion. According to Snow and researchers, children with PDD-NOS differ from those with an ASD and other developmental disorders because they exhibit more anxiety and depression once they attend school (Snow et al., 2011). According to the most recently revised DSM-V, PDD-NOS is not a separate disorder and should be diagnosed as an ASD and treatment should be the same.

Childhood Disintegrative Disorder (CDD)

Childhood Disintegrative Disorder (CDD) is considered more rare and often is associated with more severe symptoms within the ASD (Filipeket al., 1999). Children diagnosed with CDD typically have normal development up to 24 months of age, and then onset of neurodevelopmental regression rapidly occurs by three years of age. Diagnosis is usually between 36-48 months of age after a regression has been noted, but it can be diagnosed as late as ten years of age (Volkmar et al., 1997). Symptoms are typically on the severe end of the Autism Spectrum Disorder, Level 2 or 3 (Filipek et al., 1999).

Incidence and Prevalence

Today, Autism Spectrum Disorders have been reported to affect one in 68 children in the United States and one in 48 boys (CDC, 2014); boys are five times more likely to be diagnosed with an ASD than girls (CDC, 2014). Autism Spectrum Disorders are the fastest growing and longest term developmental disability in the United States (Autism Speaks, 2012). Currently, Autism Spectrum disorders cost the nation approximately $137 Billion per year.

Diagnosis of ASD

Children can be reliably diagnosed with an ASD between two and three years of age by an experienced clinician (Stone,et al. 1999). The criterion for an ASD diagnosis is based on The Diagnostic and Statistical Manual 5 (DSM-5) for mental health disorders (2013). Presently, there is no medical test for an ASD. More often than not parents are the first to identify areas of concern. Pediatricians typically conduct developmental milestone screenings from when a child is born through three years of age. If a parent and/or a medical provider have concerns, then an ASD screen is administered and completed by a trained medical provider. The Modified Checklist of Autism in Toddlers (M-CHAT) is a list of questions about a child and their developmental history. The screening tool should be used to determine if a child needs further evaluation by a specialist such as a developmental pediatrician, neurologist, psychiatrist and/or a psychologist. Often diagnosing an ASD has been done by a multi-disciplinary team of specialists (e.g., medical doctor, psychologist and/or mental health provider, occupational therapist, speech therapist) and has been based on a comprehensive assessment. This assessment typically included a detailed history of medical conditions and developmental concerns by the primary caregiver. It was followed by trained professionals conducting a standardized assessment using the autism diagnostic observation schedule (ADOS), and/or the childhood autism rating scale (CARS) along with standardized methods for diagnosing speech and language deficits and oral and motor impairments. Refinement in ASD diagnostic tools is ongoing in both clinical practice and research since an ASD has a wide range of symptoms and the etiology is still unknown.

Treatment of ASD

There is much controversy and debate in the area of the treatment of ASDs since limited research is available and there is no cure at this point in time. Although no cure exists, there are numerous treatment options. Treatments have included educational, developmental, dietary, and pharmacological treatments, complementary and alternative medicine, occupational therapy, and speech and language therapy. According to the Green et al., (2004) survey of 552 parents, the mean number of interventions that families participated in at a given time for their child was seven (Green et al.,2004). Speech therapy was the most common type of intervention, followed by visual schedules, applied behavior analysis and occupational therapy (Green et al.,2004). There has been general agreement within the professional community that the best type of treatment involves intensive developmental therapies, special education and behavioral management (Levy et al., 2002).

Therapeutic and behavior-based interventions

There are several developmental and behaviorally based interventions used to improve symptoms and impact children with an ASD. Commonly used models are: The Denver model, Developmental Individual Difference Relationship-Based (DIR) model, Relationship Development Intervention (RDI) model, and Applied Behavioral Analysis (ABA) model (Table 1). These models can be implemented by professionals and/or managed by family members with proper training and continued supervision.

The Applied Behavioral Analysis (ABA) model is a scientific approach to the study of behavior and behavior changes. ABA is an umbrella term that is comprised of a variety of concepts, principles, and techniques that are used in the assessment, treatment, and prevention of undesired and desired behaviors associated with an ASD. ABA is defined as the direct application of behaviorism to impact and improve human behavior (Axelrod et al., 2012). Over the past sixty years the principles of ABA have been empirically supported to treat symptoms of an ASD (Green et al., 2004). The principles of ABA are some of the most effective means to treat an ASD (Filipek et al., 1999) since ABA concentrates on skill acquisition associated with the core deficits of an ASD. In early development communication, social interaction and play schemas are implemented by trained professionals while applying the ABA principles (National Research Council, 2001). A study conducted by Ivar Lovaas in 1987 demonstrated that children with an ASD who received 40 hours of direct ABA intervention achieved IQ scores of greater than 100, and language and behavioral improvements were made (Lovaas, 1987). There were several limitations in this trial; it lacked randomization of the participant to the experimental or control group, the sample size was small, and maturation was not addressed. However, today ABA therapy is considered highly beneficial for individuals diagnosed with an ASD, and more often than not improvements in the core deficits of an ASD are made.

The Early Start Denver Model (Rogers et al., 2009) focuses on remediating core deficits by using imitation, emotion sharing, theory of mind, and social perception by incorporating play, relationships, and activities to stimulate symbolic thought. The DIR Floor time model focuses on play sessions in order to enhance relationships, emotional sharing and social interactions (Greenspan et al., 1997). The RDI model focuses largely on activities that elicit interactive behaviors with the goal of increasing the child's desire to be connected with people and discover the value of having meaningful relationships (Gutstein et al., 2002). This latter model engages the child to participate in everyday activities such as sweeping the kitchen floor, cracking eggs in order to bake a cake, and creating opportunities for play while interacting with family members and/or loved ones.

Table 1. Types of Early Interventions commonly used to treat symptoms of an ASD

Applied Behavior Analysis	Scientific approach to the study of behavior and behavior changes.
The Early Start Denver Model	Focuses on remediating core deficits by using imitation, emotion sharing, theory of mind, social perception using play
DIR Floor Time	Focuses on play sessions in order to enhance relationships and emotional and social interactions
Relationship Development Intervention (RDI)	Focuses on activities that elicit interactive behaviors with the goal on increasing the child's desire to be connected with people

Research has illustrated the benefits of early intervention through improvement of symptoms in children with an ASD. Not only are ASDs treated through developmental appropriate models, but other therapies co-exist such as speech therapy, occupational therapy, auditory therapy, art therapy, physical therapy, hippo-therapy, social skills therapy, and sensory integration therapy. Due to secondary diagnoses and no cure currently available, medical interventions and complementary and alternative therapies are widely used.

Dietary Interventions

Within the last decade dietary interventions have become increasingly popular among families of children with an ASD. Survey results indicate that 15% to 38% of families have tried and/or are currently using a dietary intervention to help treat symptoms of an ASD (Green et al., 2004). Most dietary interventions used to treat symptoms of an ASD involve eliminating at least one or more types of food from the child's diet such as wheat (gluten), milk (casein), soy, yeast, additives, sugar, eggs, and yeast (Cornish, 2002). The most common dietary intervention is a gluten and casein free (GFCF) diet. Families receive information regarding diet and nutritional therapies from other parents, internet sites, unpublished sources, autism organizations, complementary and alternative medical providers (Arnold et al., 2003). Many dietary interventions have shown little, if any, evidence supporting or refuting their efficacy and effectiveness; however, they continue to gain in popularity. Also, there is a small body of evidence linking the GFCF diet to suboptimal bone development, specifically reduced bone cortical thickness (Mulloy et al., 2010). Some dietary interventions also add additional stress for the family due the financial burden, time commitment, and possible increase in social isolation due to food restrictions.

Pharmacological Interventions

Psychotropic medications are often used to minimize maladaptive behaviors, improve anxiety, stabilize moods, and to improve an individual's ability to socialize. An assortment of stimulant medications is often prescribed to treat symptoms of impulsivity, hyperactivity, and short attention span. Antidepressants and antianxiety medications are used in individuals with an ASD in the same way as individuals without an ASD. Antifungals are often prescribed by complementary and alternative medical providers to treat yeast overgrowth if an individual is suffering with gastrointestinal symptoms (Wink et al., 2011).

Complementary and Alternative Medical Interventions

Today, the use of complementary and alternative medicine (CAM) has steadily increased in western society, especially in the pediatric population. CAM interventions have been reported to occur at a rate as high as 85% in families who are treating a child with autism (Wong, V.C.N., 2009). Despite a lack of evidence-based trials, these treatments continue to gain in popularity among families and providers. There are several types of CAM therapies being used to treat ASDs such as dietary interventions, biomedical, vitamins and minerals, chelation, and music therapies, cranial sacral, acupuncture, hyperbaric chambers, etc. Parents have discovered CAM interventions through the internet, media, anecdotal reports and autism support organizations (Levy and Hyman, 2002). The primary goal of CAM interventions is to prevent or treat illnesses “naturally,” to promote a person’s overall well-being, and to remediate symptoms of an ASD (Wong, V.C.N., 2009).

Section Two: Investigating a Nutritional Connection in Children with an ASD

Dietary intake in children with an ASD appears to differ from typically developing children (Cornish, 1998; Schreck et al., 2004; Lockner et al., 2008; Eaves and Ho, 2008; Herndon et al., 2009). Even though dietary intake appears to differ between children with an ASD compared to typically developing children, the research has reported conflicting results (Zimmer et al., 2012).

Emond and colleagues (2010) conducted a prospective study using a population-based cohort to examine feeding patterns, diet and growth in children who were born between April 1992 through December 1999 and who lived in Avon, England. The expecting mothers (n=14,541) enrolled during their pregnancy. The study included n=12,901 children who were typically developing and n=79 who were diagnosed with an ASD. All mothers completed a demographic, medical questionnaire along with a food frequency questionnaire (FFQ). The FFQ results indicated that children with an ASD, compared to the typically developing children, consumed fewer vegetables, salads, fresh fruit (p<.05) but fewer sweets and carbonated beverages (p<.05). There were no significant differences between the two groups when comparing macronutrient intake (total carbohydrates, total protein, and total fat) (Emond et al., 2010).

In 1998, Cornish, a Registered Dietitian, interviewed parents of 17 children with an ASD, ranging from age three years six months to nine years nine months. The interview included a three day dietary recall (two week days and one weekend day), and a food frequency checklist was given to assess nutrient intake. Participants’ nutrient intakes were compared to the reference nutrient intakes (RNI) for a child of the same age and sex (Department of Health 1991), while energy intakes were compared to the estimated average requirements (EAR). Number of servings and percentages of macro- and micronutrients of interest were calculated. The results illustrated that 71% (12) participants consumed fewer than two servings of fruit and vegetables (recommended servings for fruit and vegetables were five portions) and 35% of the participants did not eat red meat; meat products and iron was primarily consumed in non-heme sources (non-heme sources: green leafy vegetables). As food variety decreased, so did nutritional status. Due to the small sample size and no comparison group, it is difficult to generalize the findings (Cornish, 1998).

Matson and colleagues studied the differences among children with an ASD, atypically developing and typically developing children's eating behaviors and how their sensory processing abnormalities affected their food intake (Matson et al. 2003). The researchers recruited 276 participants: autism (n=72), PDD-NOS (n=40), atypically developing (n=53), and typically developing (n= 114). They ranged in age from three to16 years (M=8.21, SD=3.76). The participants' parents or primary caregivers completed two questionnaires. The ASD-Diagnostic for Children (ASD-DC) and the ASD-Comorbidity for Children (ASD-CC; Matson et al., 2003) were used to assess symptoms of autism and the co-occurring behavioral and emotional difficulties that are often associated with ASD. There were eight items that addressed eating behaviors and one item that addressed sensory abnormalities from the assessment instruments. Nonparametric tests compared the differences among the groups. The results showed that both the ASD and PDD-NOS groups had approximately the same frequency of feeding problems without significant differences in any of the nine items observed between them. However, the ASD and PDD-NOS groups significantly differed for six out of the nine items (p<.0125) when compared to the atypically and typically developing groups. This study had some methodological shortcomings such as there was not a long-term follow up, all data were based upon parent or caregiver report, and the ASD-DC and ASD-CC were not specifically designed to target feeding and mealtime behaviors. The ASD-DC was limited to one item out of 40 pertaining to eating, and the ASD-CC had eight questions reflecting food behaviors and growth status. These were not comprehensive assessments of eating and feeding behaviors; therefore, it is not possible to generalize the findings to a larger population. Also, it is difficult to determine how age effects intake in these results since the age range was large and not analyzed in categories.

Schreck et al., designed a study to evaluate sensory processing and dietary intake in children with an ASD while comparing them to typically developing children, (n=298 controls and n=138 ASD), ranging from age seven to nine-and-a-half years (Schreck et al., 2004). Children with an ASD experienced more general feeding problems in comparison to the children who were typically developing (p <.001). The ASD group of children consumed fewer servings from fruit, vegetables, dairy, non-dairy proteins, and starches, and 72% of the children with an ASD consumed a narrower variety of foods. The results supported previous studies (Raiten and Massaro, 1986; Cornish, 1998) and illustrated that children with an ASD may be more likely to restrict food, by texture or type of food, and are more likely to refuse foods when compared to typically developing children (Schrecket al., 2004).

Lockner and colleagues (2008) conducted a cross-sectional descriptive pilot study to compare dietary intake in 19 typically developing (TD) preschool aged (three to five years) children compared to 19 children with an ASD. The participants' parents completed a three day food record and a survey that was designed for this study regarding mealtime behaviors that were present in their children. Dietary intakes were compared to Estimated Average Requirements (EAR) and Adequate Intake (AI) for calcium and fiber since EARs were not available. Based on the three day food records, no significant differences in nutrient intakes were noted between the two groups. Vitamin A (ASD= 53%; TD= 20% below EAR) and vitamin E (ASD=86%; TD=93% below EAR) were consumed in low amounts. Parents of typically developing children reported less problematic mealtime behaviors compared to parents of children with an ASD. Problematic mealtime behaviors were reported to occur more often in children with an ASD when compared to typically developing children. Parents of children with an ASD reported that their children had favorite food textures ($p<0.001$), were picky eaters ($p<0.002$), and often refused to eat new foods ($p<0.01$). Even though parents were trained on how to complete the three-day food record, under- or over-reporting is an inherent problem when recording dietary intake. Another limitation in this study was the small sample size, thus limiting statistical power.

According to Johnson and colleagues (2008), there were no significant differences among children with an ASD (n=19) compared to typically developing children (n=15) in macronutrient intake. Enrolled parents were asked to complete several questionnaires, a Feeding Assessment Survey, a Food Frequency Questionnaire (FFQ), a 24-hour food intake interview, and a Child Behavior Checklist

(Achenbach. 2000). While there were differences in types of foods accepted between the two groups, there were statistically significant feeding behaviors in four out of the ten feeding assessment questions between the children with an ASD compared to the children who were developing typically. Based on parent reports, children with an ASD threw food more often (p=.03), refused foods of certain texture (p<.000), color (p<.008), and from specific food categories (p<.000) more often when compared to children who were typically developing (Johnson et al., 2008).

A study conducted by Herndon and colleagues investigated the nutrient intake of 46 children with an ASD and 31 children who were typically developing. Parents were trained and asked to complete a three day food record for their enrolled child. Results from three day food records illustrated that children with an ASD consumed significantly more non-dairy proteins and significantly less dairy food items (p<.05) when compared to the typically developing children (Herndon et al., 2009). The children with an ASD also consumed less calcium but more vitamin B6, and vitamin E. These results supported other existing data (Cornish, 1998; Schreck et al., 2004) about nutrient intake in children with ASD (Herndon et al. 2009). A sub-group of children with an ASD who were consuming the gluten- and casein-free diet were evaluated as well. Findings illustrated that children on the GFCF diet consumed more vitamin E, but there were no other statistically significant differences between children with an ASD consuming a typical diet compared to the children with an ASD who were consuming a GFCF diet. Another interesting finding is that even though mean intakes of most macro- and micronutrient intakes were similar among the groups,, children with an ASD had a wider range of intakes, more on the extreme ends of the ranges (Herndon et al., 2009).

Section Three: Gastrointestinal Connection and Typical and Atypical Eating in Children

Gastrointestinal (GI) symptoms

Interest in the connection between gastroenterology and ASDs is not new as it has been established that gastrointestinal disorders are more common in children with neurological disorders (Melmed et al., 2000). As early as the 1970s, ASDs and gastrointestinal (GI) symptoms were reported (Goodwin et al., 1971) with the goal of identifying a sub-type of autism. Reports of the prevalence of GI symptoms in children with an ASD vary from 9-52% (Kuddo et al., 2003; Valicenti-McDermot et al., 2008). Possible explanations for gastrointestinal symptoms in children with autism are multi-factorial. GI symptoms in children with ASD could be due to genetics, immunologic factors, embryologic and/or neurological factors. Gastrointestinal problems encompass a wide range of symptoms. The most common GI symptoms reported for children with autism are: reflux, chronic gastritis, abdominal pain, distention, food intolerance, food selectivity, constipation, and diarrhea (Erickson et al., 2005; Levy et al., 2005).

Valicenti-McDermott and colleagues in 2008 conducted a cross-sectional study that compared GI symptoms (cramping, abdominal pain, constipation, diarrhea, bloating) and family history of autoimmune diseases in a sample of 50 children with an ASD, 50 children with other developmental disorders, and 50 typically developing children. Their results illustrated that 70% of children with an ASD parents reported GI symptoms compared to the 42% of children with other developmental disorders and 28% of typically developing children. The differences were statistically significant between the three groups (p<.05), revealing that GI symptoms were more prevalent in children with an ASD (Valicenti-McDermott et al., 2006).

Horvath et al. (1999) conducted a retrospective comparative study which included 412 children (mean age 6.5 years ± 3.6 years) with an ASD who suffered with at least one GI symptom, and parents were asked to complete the same questionnaire for 43 healthy, age-matched siblings for the control group. The results illustrated that 84% of children with an ASD had at least one GI symptom compared to 31% of the siblings who were typically developing ($p<0.0001$). In addition, the results suggested that there was a greater incidence of children with an ASD suffering with multiple GI symptoms when compared to typically developing individuals (Horvathet al., 1999).

Afzal and colleagues conducted a retrospective chart review study of 103 children with an ASD who were referred to a gastroenterology clinic (Afzal et al., 2003). They included 29 children who were typically developing and who were also referred to the gastroenterology service due to GI complaints. The results illustrated that constipation was more frequent in children with an ASD when compared to the children who were typically developing (36% compared to 10%). An unexpected finding demonstrated that the consumption of cow's milk seemed to be the primary predictor of constipation. The milk protein, casein, has been suggested by other researchers to cause chronic constipation due to an "allergic dysmotility" (Afzal et al., 2003).

Ming and researchers conducted a retrospective chart review of 160 children with an ASD looking at the clinical concurrent disorders to determine whether phenotypic subgroups in children with an ASD could be identified (Ming et al., 2008). Constipation, diarrhea, and bloating affected 59% of the children and 51% of the children experienced long-term food intolerance. More than 50% of the participants had food intolerance, GI dysfunction, and sleep disorders. As food intolerances may lead to GI dysfunction, these co-occurring disorders may all be correlated and more prevalent in children with an ASD (Ming et al., 2008).

Despite anecdotal and clinical trial reports that children with an ASD have a higher frequency of GI symptoms, epidemiological data do not support this claim (Blacket al., 2002). Currently the existing data pertaining to the frequency of GI symptoms in children with an ASD have several methodological shortcomings. A large portion of the published studies have had relatively small sample sizes, no control groups or the control group participants were poorly matched. Another methodological shortcoming is that parents over reported GI problems in their children with an ASD. Finally another significant shortcoming was that several studies had a referral bias since the participants were pre-selected for the study and/or referred to or were seen by a GI doctor. Despite the potential for over-inflated reported prevalence of GI symptoms in children with an ASD, complementary and alternative providers often prioritize their treatments to heal GI dysfunction (Levy, 2005). This was likely due to the existing research supporting GI dysfunction and the continual parent reports of gastrointestinal problems in their children with an ASD.

Digestive dysfunction and increased intestinal permeability

It has been hypothesized that a sub-group of children with an ASD do not produce and/or efficiently utilize the digestive enzymes necessary to break down certain proteins such as gluten and casein. This incomplete digestive process could potentially leave undigested peptides in the small intestine (Cass et al., 2008). Some researchers have also suggested that the transfer of these peptides across the lumen occurs at an increased rate in some children with an ASD. This has been referred to as a “leaky gut” in individuals with an ASD (Christison and Ivany, 2006).

A commonly referenced study conducted in 1996 indicated that the pathological findings in the GI tracts of 25 children with autism were atypical (D'Eufemia P, 1996) and that there were inflammatory and immune changes in children with ASD. These changes led to an increase in intestinal permeability in 43% of the children with ASD, and 0% in 40 typically developing children. There was an associated adverse reaction in the central nervous system due to the increase in intestinal permeability. It was suggested that this reaction could potentially affect development and behavior in children with an ASD (D'Eufemia et al., 1996).

Vojdani and colleagues studied 50 children with an ASD and 50 typically developing children (Vojdani et al., 2004). They examined each participant’s serum to see if IgG, IgM, and IgA antibodies against gliadin and cerebellar peptides were present. The children with an ASD showed higher serum amounts of IgG, IgM, and IgA antibodies against gliadin and cerebellar peptides when compared to the healthy controls ($p<.05$). They concluded that a subgroup of ASD participants produced antibodies against Purkinje cells and gliadin peptides. They hypothesized that these undigested compounds, also known as exomorphins, are then transported across the lumen in the small intestine into circulation where they can affect cognitive function. Their findings suggested that if gluten and casein were removed from the diet, the production of opioid-like peptides would be inhibited and autism-like symptoms would decrease (Vojdani et al., 2004). The significance of elevated urinary peptides and leaky gut theory related to gluten and casein remain unclear and somewhat controversial and researchers investigating this theory have produced conflicting results (Mulloy, 2010).

Another possible reason for digestive problems in children with an ASD is food sensitivities (Elder, 2008). Recent evidence has suggested that some children with an ASD, who also have food sensitivities, have an impaired ability to enzymatically break down and absorb some proteins which may chronically affect digestion (Arnold et al., 2003). A food sensitivity is an autoimmune response involving an IgG antibody reaction versus an IgE reaction, which is associated with a food allergy. Food sensitivities can damage different tissues and, as such, food sensitivity is thought to stem from an inability to digest food efficiently leading to inflammation, gut injury, and potentially the production of neurotransmitters such as opiates (Shattock et al., 1991; Ming et al., 2008). Food sensitivity can be inherited or possibly develop from a leaky gut syndrome. Wheat and dairy are proposed to be the most common food sensitivities in children with an ASD (Reichelt et al., 1990). A food sensitivity is suggested to have negative consequences in children with autism. Food sensitivities are associated with irritability, food refusal, sleep disturbances, constipation, and diarrhea in children with an ASD (Jyonouchi et al., 2005; Levyet al., 2005; Cormier et al., 2007).

Gastrointestinal Symptoms and Inflammation in Children with an ASD

Another theory that is popular about the connection between gastrointestinal symptoms and an ASD is the notion of increased gut inflammation among children with an ASD. Intestinal inflammation is the disruption of the interaction of all cells in the mucosa (Ericksonet al., 2005). Ashwood and colleagues have been instrumental in testing the hypothesis of increased intestinal inflammation in ASD children. Ashwood et al. have suggested that a subgroup of children with an ASD may suffer from dysregulated intestinal mucosal immunity with an increase in pro-inflammatory cytokine production (Ashwood et al., 2003). One of their studies compared duodenal and colonic biopsies in 52 children with an ASD, and 79 children who were typically developing. Results indicated an increased pro-inflammatory response with CD3+ lymphocyte cytokines and decreased regulatory activities in the mucosa of the children with an ASD ($p<.05$). Data further supported the conclusion that there may be a group of children with an ASD suffering from mucosal immunopathology. This study had an extremely small sample size; therefore, it would be difficult to generalize these findings to a larger and more heterogeneous population.

Immune function and GI symptoms in children with an ASD

Another hypothesis regarding children with an ASD and gastrointestinal symptoms is that they have an impaired immune system. (Levy and Hyman, 2002; Levy and Hyman, 2003). Impaired immune function can cause reliance on antibiotics. Antibiotics can have side effects that damage the gut flora, compromise digestion, and weaken an individual’s ability to fight viruses and bacterial infections (Bolte, 1998). It is suggested that antibiotics are one of the most common causes of yeast overgrowth in a person’s GI tract which can cause inflammation (Bolte, 1998). Parracho and colleagues conducted a study which included 58 children with an ASD and two control groups (12 typically developing siblings and ten typically developing children from the general population). The study included a parent interview aimed at identifying GI symptoms, dietary intake, and to determine the use of antibiotic therapies. Results indicated that antibiotic use among the children with an ASD was greater when compared to the two control groups. Out of the 58 children with an ASD, 52 had received antibiotics compared to five in total from the control groups. Of the 52, 20 of the ASD participants received more than six rounds (treatments) of antibiotics while there were no reports of the two control groups receiving that amount of antibiotic treatment (Parracho et al, 2005). Repeated use of antibiotics may be a compounding factor in children with an ASD in that frequent antibiotic use may compromise a child's immune defense by altering their gut flora (Parracho et al, 2005), thus impacting their gastrointestinal function.

What is not understood is whether symptoms of GI dysfunction impair an immune system or whether the immune system is compromised, thus potentially impacting the development of GI dysfunction in children with an ASD. Researchers continue to study the connection between GI symptoms and Autism Spectrum Disorders.

Definition of Typical Feeding Behaviors

The act of eating is most often instinctive along with a learned response (Eicher, 2004; Arvedson and Brodsky, 2002). The process begins after birth when the infant consumes breast milk and/or infant formula. The development of typical feeding skills is influenced by a number of factors and varies in all children. As a result, problems in any one area can result in feeding disturbances. Factors include the growth and development of anatomical structures required for feeding, medical status of a child, social and emotional development along with environmental factors (Linscheid, 1995; Linscheid, 2006). The act of eating involves the processing of sensory information across a range of modalities: vision, taste, smell, and touch (Coulthard and Blissett, 2009). Table 2 illustrates an approximation of typical development of eating and drinking skills in children.

Table 2. Typical Development of Eating and Drinking Skills in Children

Age	Feeding Skill
2-4 months	Infant brings hand to mouth, infant brings hands to mouth holding an object, pats bottle with hands, holds bottle
5-7 months	holds bottle, mouths and/or gums solid foods, drinks from cup held by an adult, infant eats cracker independently
9-14 months	Finger feeding takes place, infant holds spoons, holds cups and drinks with some spilling, imitates stirring with a spoon, brings filled spoon to mouth
15-18 months	Child scoops food and brings it to mouth
18-24 months	Child drinks from cup, no longer a bottle and brings feeding utensils to the mouth
30-36 months	Child can pour liquids from small containers, feeds self with very little spilling, uses a fork to stab food

Morris SE, Klein MD. Pre-feeding Skills: A Comprehensive Resource for Mealtime Development. 2nd Edition. 2000.

As the infant grows and develops, she begins to consume pureed foods and semi-solid foods, typically between four to six months of age (Morris, 2000). If an infant is exclusively breastfed, it is recommended to begin complementary foods at four months if developmentally appropriate (Michaelson, 2009). Between nine and 14 months of age, an infant/toddler learns how to pick up and eat finger foods (Morris, 2000).

Definition of Atypical Feeding Behaviors

Feeding problems are defined as limitations to the intake of adequate nutrition that can occur because of structural abnormalities, neurological conditions, behavioral problems, cardio-respiratory problems, metabolic dysfunction (Burklow et al., 1998), sensory sensitivities (Schwarz, 2003), and oral and fine motor impairments (Amato, 1998; Green, 2002; Field and Garland, 2003). Feeding problems are common in childhood; they reportedly occur in 25% to 35% of typically developing children (Burklow et al., 1998) and in 46% to 89% of children with an ASD (Cornish, 1998; Ahearn et al., 2001; Bowers, 2002; Cornish, 2002; Field and Garland, 2003; Schreck et al., 2004).

Feeding problems can be complex and are often multi-factorial which can impact a child's health and well-being.

Section Four: Investigating a Sensory Connection to ASD

Definition of Sensory Integration Dysfunction/Sensory Processing

Sensory Integration Theory (SIT) was developed by Jean Ayres (Mulligan, 1998; Miller, 2000; Bundy, 2002; Minshew and Hobson, 2008) and many occupational therapists and researchers have continued to study the theory (Dunn and Brown, 1997; Dunn et al., 2002). Sensory Integration is a term that has been used to explain neurological function which involves organizing sensory input in a useful way so an individual can participate effectively within his/her life (Ayres, 1979). It has been posited that children who experience sensory processing dysfunction may have undesirable emotional and behavioral responses to their environment (Ayres, 1979; DeGangi, 1991; Williamson, 1997). Ayres's Sensory Integration theory has its theoretical foundation in neuroscience and is thought of as a theory, a model, and a frame of reference in the field of occupational therapy (Kuhaneck, 2010). According to Schaaf and Davies, there is minimal evidence to support the term Sensory Integration and/or Sensory Processing and more research is necessary to accurately define the constructs of sensory integration/sensory processing (Schaaf, 2010). The term sensory integration/sensory processing will both be used interchangeably in this paper.

Sensory Integration/Sensory Processing Theories Relating to an ASD

Researchers began investigating sensory processing theories in children with ASD during the 1970s (Ayres and Tickle, 1980; Baranek and Berkson, 1997a). Ayres studied children with an ASD and found that they often suffered with differences in processing sensory input which may cause undesirable behaviors seen in children with an ASD (Ayres, 1979; Ayres and Tickle, 1980). Parents have often reported unusual sensory responses in their children with an ASD, and research has suggested that 30%-100% of children with an ASD experience some type of sensory processing dysfunction (Birch L.L., 1987; Greenspan, 1997; Watlinget al., 2005; Leekam et al., 2007; Bandini et al., 2010). Four hypotheses pertaining to children with an ASD and sensory processing can be characterized as over-arousal, under-arousal, perceptual inconstancy, and impaired cross-modal processing theories. Children who suffer with over-arousal sensory dysfunction appear to be easily aroused and reactive to sensory stimuli. They may also appear to be slower to adapt to stimuli in the environment when compared to typically developing children (Rogerset al., 2003). Under-arousal theories have been discussed by Rimland, founder of the Defeat Autism Now! (DAN!) movement (Rimland, 1964). Rimland suggested that children with an ASD have an impaired ability to make an association between past and present experiences, thus preventing learning and generalization that can contribute to a lack of typical responses to stimuli (Rimland, 1964). The perceptual inconstancy theory was developed by Ornitz and Ritvo in the early 1960s (Ornitz and Ritvo, 1968). The researchers suggested that children experience abnormalities in perceptual integration and processing motility patterns. They suggested that children with an ASD have abnormal states of arousal due to brainstem abnormalities, which can result in over-excitation and/or over-inhibition. The cross-modal theory suggests that children with an ASD may have abnormalities in the hippocampus region of the brain. These abnormalities can cause failure to process incoming sensory information from the same event in an appropriate way (Brock et al., 2002).

Sensory Dysfunction Regarding Feeding Behaviors in ASD Children

Feeding problems for children with an ASD include food refusal, food selectivity, rituals related to food and mealtime, sensory aversions, and defiant behaviors (Williams et al., 2000). Sensory processing impairments are often discussed in conjunction with food selectivity and food refusal in children with an ASD. Food selectivity by *type* refers to eating a narrow range of food that may be nutritionally inadequate. Children in this group (food selective by type) are differentiated from the children with food refusal based on the fact that they are able to maintain appropriate growth (Munk and Repp, 1994; Ahearn, 2001; Williams, 2008). Children in the food selectivity category by type are referred to as “picky” or “fussy” eaters (Feucht, 2010). Food selectivity by *texture* is the refusal to eat developmentally appropriate food textures (Ahearn et al., 2001; Munk and Repp, 1994; Williams et al., 2008). Food selectivity has been described as sensory-based (Schwartz, 2003). These unusual eating habits can interfere with the child’s ability to consume an adequate amount and variety of foods necessary for healthy growth and development. It has been suggested that there are implications for nutrient insufficiency in children with ASD compared to typically developing children (Herndon et al. 2009; Cornish, 1998; Schreck et al., 2004).

Children with ASD Are More Likely to Suffer with Sensory Abnormalities When Compared to Typically Developing Children.

Review of current evidence-based research, clinical reports and observations, 30%-100% of children with an ASD suffer with sensory processing abnormalities (Dawson and Watling, 2000). Leekam and colleagues conducted two studies simultaneously examining sensory abnormalities in individuals with ASD using the Diagnostic Interview for Social and Communication Disorders (DISCO) (Leekam et al., 2007). The first study consisted of two trained researchers conducting parent interviews using the DISCO. Participants included 33 ASD children (n=16 low functioning (LF), n=17 high functioning (HF) compared to n=19 children with developmental delays (DD), n=15 children with language disorders (LD), and n=15 typically developing (TD) children. Participants in the clinical groups: HF, LF, LD, DD and TD were matched within six months of each other's ages, and were also matched on nonverbal IQ scores. One-third of the children in each clinical and comparison group were between the ages of two years ten months to five years seven months. One-third of the remaining group was aged six to eight years, and the final one-third was between the ages nine and 11 years. Individual matching was not possible for seven children but a close group-wise match was achieved showing no statistical differences between HF and LI group (t=.213, df = 33, p=.833) or between LF and DD groups (t= .365, df = 33, p = .717). Non-verbal language tests were conducted by one of the two researchers within a few days after the DISCO interview. The results indicated that there was a statistically significant difference between the children with ASD (LF + HF) having sensory abnormalities when compared to the two comparison groups (LI + DD). The ASD group had significantly higher mean total scores on the 25-item assessment (M=5.09, SD= 4.16) than the combined LI and DD groups (M= 1.94, SD= 2.47). The chi-square analyses for each sensory domain (visual, smell, touch, mixed proximal) showed that children with an ASD had significantly more sensory symptoms (p<.001) when compared to children in the comparison groups. These results support previous studies that children with an ASD experience more sensory abnormalities than typically developing children (Leekamet al., 2007). There were several limitations in this study such as small sample size, and the scoring may not have differentiated the severity of symptoms since the DISCO was originally designed to assess behaviors and developmental skills in children with social and communication disorders, not an ASD. Therefore, another assessment instrument might have yielded different results.

The second part of the study included 200 children and adults with ASD (low functioning young (LFY), low functioning old (LFO), high functioning young (HFY), high functioning old (HFO), aged 32 months to 38 years (M= 12.7 years, SD= 8.1). Researchers were interested in determining if the frequency and/or pattern of these sensory symptoms change with age and ability level (Leekam et al., 2007). Based on the age of the participant, ability levels were assessed using the Wechsler Intelligence Scale for Children (WISC-III-UK), the Wechsler Preschool and Prima Scale of Intelligence (WPPSI), the Wechsler Adult Intelligence Scale (WAIS), the Leiter International Performance Scale or the Merrill Palmer. Language was assessed from part of the Wechsler tests, the British Picture Vocabulary Scale or the Reynell Language Development instrument. Once again the DISCO was used by the same two researchers interviewing the parents. The DISCO and the above-referenced instruments were used to estimate the ’participants’ ability levels. After the initial assessments were completed, participants were placed into one of the four groups: young low IQ (N=35), young high IQ (N= 65), old low IQ (N=35) and old high IQ (N=65). Findings showed that 185 out of 200 (92.5%) had at least one sensory abnormality. Results indicated that there were no statistically significant differences between the age and IQ groups when comparing sensory symptoms. Two sensory domains (visual and oral) reached significance at .01 for the number of participants and the number of symptoms. The results indicated a negative correlation between aging and sensory symptoms. The older individual suffered significantly less with other oral symptoms than the younger participant. The visual domain (i.e., preoccupation with shiny objects and bright lights) illustrated that there were significant differences among all groups. The most significant limitation of this study was the relatively small sample size and the assessment of the participants "ability" since more than one instrument was used and the reliability and validity of these instruments were not described or discussed. Another limitation of study two was that the group differences could not be generalized to a larger population based on age and IQ differences without further research. This was a cross-sectional study, and all assessments were done by parent report (Leekham et al., 2007).

Kern et al. conducted a cross-sectional study evaluating auditory, visual, oral and touch sensory processing in children with ASD (Kern et al., 2006). One hundred and four participants with ASD, ages three to 56 years were gender- and age-matched to typically developing individuals. Convenience sampling occurred by recruiting participants from the Autism Treatment Center in Dallas and San Antonio along with local autism societies. Typically developing participants were identified from the Dallas Metroplex and Collin County area. Participants were grouped into seven categories (ages 3-7, 8-12, 23-27, 28-32, and 33-older) and each group included a minimum of 12 participants. A family member, therapist, teacher, job coach, facilitator, or group home manager completed the Short Sensory Profile (SSP) (Dunn and Brown 1997) instrument and the Childhood Autism Rating Scale (CARS) for the participants with an ASD. The SSP were completed by either the participant (38%) or the primary caregiver in the control group. Four sections of the SSP were analyzed: visual processing, auditory processing, oral sensory processing, and touch processing (Kern et al., 2006).

There were significant mean differences in all four sensory domains between the ASD group and control group. These results concluded that as the participant in the ASD group ages, sensory abnormalities decrease. For example,, the ANOVA for auditory processing showed a significant main effect for the group with an ASD (F(1, 194)=95.21, p<.0001) and there was also a main effect for age (F(6, 194)=3.14, p<.006), which illustrates that there is a difference between the ASD group and the control group regarding changes in auditory processing with age. The findings are supported by the current literature and parent reports which show significant group differences in auditory, visual, touch and oral sensory processing (Kern et al., 2006). There were a number of strengths in this study. These include a fairly large sample size (n=208); the use of a valid assessment instrument and the statistical analyses were able to detect differences, but a limitation in the study was that there were no clinical observations to determine and confirm the sensory processing abnormalities that were reported in the SSP.

Tomchek and Dunn (2004) conducted a retrospective chart review to examine the differences in sensory processing in ASD children compared to typically developing children (Tomchek and Dunn, 2007). Children with an ASD were recruited using existing data from a tertiary diagnostic center and the typically developing children were recruited using data from a national study. The two comparison groups were matched according to age (three to six years of age) and when possible were matched for sex. A total of 562 participants were included, n=281 in each group. The ASD group had 256 with autism, 21 with PDD-NOS, and four with Asperger's syndrome. The Sensory Profile Questionnaire (SSP) was used in its shorter version (38-item questionnaire). Total score comparisons showed that 84% of the ASD participants obtained different scores in sensory processing when compared to 3.2% in the typically developing group. Findings indicated that participants in the ASD group performed differently from the typically developing group (p<.001) in all SSP sections and for the total score. The effect size ranged from .219-.628, which is small to medium; thus indicating that the differences are likely to be meaningful according to Cohen (1988). These results are similar to the previous studies reviewed, indicating that there are statistically significant differences in sensory processing in children with ASD compared to typically developing children (Tomchek and Dunn, 2007). A drawback in this study was that no new data were collected since it was a retrospective chart review; therefore, all analyses were based on what was available. Also, there were no clinical observations or videotapes to confirm the SSP results. All of these studies provide evidence of sensory processing differences in children with an ASD compared to typically developing children.

Sensory Processing Difficulties and Problematic Eating Behaviors in Children with an ASD

Numerous parent and professional reports of children with an ASD state that sensory factors, such as smell, taste, texture, color and temperature can affect whether a child will consume food (Cermaket al., 2004). Some researchers have speculated that sensory sensitivities cause an increase in food selectivity in children with an ASD. Children with an ASD often experience hypersensitivity in and around the mouth

(Schwarz, 2003). Children with an ASD often experience spitting, coughing, gagging, or vomiting when they try new foods. It has been postulated that over time those experiences can limit the amount of nutritional intake, restrict the variety of foods, and create a negative interaction between the child and caregiver (Case-Smith, 1999; Harris, 2000; Bernard-Bonnin, 2006). Eating is an activity that may be negatively affected by sensory processing difficulties (Cermak et al., 2010; Ayres and Tickle, 1980; Dunnet al., 2002). Oral defensiveness, which can be a part of tactile defensiveness, can be defined as someone avoiding certain textures of foods and activities around the mouth (Cermak et al., 2010).

As discussed in this section, sensory sensitivities may contribute to an increase in food selectivity in children with an ASD. The texture and type of foods has been consistently reported to affect food intake in children with an ASD (Wiggins et al., 2009 (p.395-410); Minshew and Hobson, 2008).

Section Five: Investigating an Motor Connection to ASD

Definition of Oral-Motor Function and Impairments.

During the first two years of life, gross, fine, and oral motor development occurs and can impact the progression of self-feeding skills (Carruth and Skinner, 2002). Table 3 shows oral motor developmental behaviors relating to feeding behaviors.

Table 3. Feeding Behaviors Relating to Oral Motor Development

Opens mouth when utensil comes to lips
Tongue moves back and forth as food enters mouth
Tongue moves food to back of mouth to prepare for swallowing
Keeps food in mouth
Uses tongue and mouth to investigate textures, shapes of food
Brings top lip down on feeding utensil to remove the food
Eats food without gagging
Chews soft foods without letting food spill out of mouth
Chews firmer foods
Chews and swallows firmer foods without choking/gagging
Chews foods that produce a liquid

Carruth, 2002

Oral motor problems may lead to difficulty using a cup or a straw or managing foods and liquids in a child's mouth. A child choosing to use asippy cup or to use fingers instead of utensils may be related to motor impairments in children with an ASD and should be evaluated. Assessment of oral and fine motor skills may provide helpful information to design and guide interventions for children with an ASD.

Oral Motor Impairments Related to Feeding Children with an ASD Compared to Typically Developing Children

A wide range of motor impairments have been associated with ASDs. Children with ASD may have difficulty feeding because of oral motor impairments (Amato and Slavin, 1998; Field and Garland, 2003). Up to 50-100% of children with an ASD suffer with motor skill impairments (Ghazuiddin, 1994; Klin, 1995; Ghazuiddin, 1998; Green, 2002). The DSM-IV does not include motor impairments as a core deficit of ASDs, but research has demonstrated that children with an ASD often suffer with motor impairments (Leary, 1996; Waterhouse, 2008), thus potentially impacting their ability to eat. Oral motor impairments include tongue thrusting, having a weak suck, poor lip closure, inability to pucker lips, blow bubbles, etc. (Geraghty, 2010).

In 1976, DeMyer highlighted motor impairments as fundamental to the expression of Autism along with the social and language problems and restricted movement that define ASDs (DeMyer, 1976). In the past decade it has been recognized that motor impairments can assist in identifying an ASD. As Mostofsky and colleagues point out, motor impairments in autism offer information into the neurological basis of the disorder (Mostofsky, 2007). Motor symptoms are some of the earliest observable behaviors that are considered reliable in helping diagnose an ASD. Rather than consider motor impairments as a comorbid condition, several professionals are viewing motor differences as integral to understanding, diagnosing and treating the symptoms of an ASD (Adams, 1998; Amato, 1998; Rogers, 2005; Gernsbacher et al, 2008).

Assessment of oral-motor and fine motor skills provide helpful information to guide the approach of intervention, although the science is not yet at a point where clear answers can be given to what motor features may or may not be included within any of the disorders that make up the spectrum.

Oral Motor Difficulties and How They Impact Feeding Behaviors in Children with ASD

Searches were conducted for specific oral motor and feeding behavior studies in children with an ASD; however, no empirical studies were found. Clinical observations, anecdotal parental and professional reports suggest that children suffering with an ASD may have difficulty feeding because of oral motor impairments (Amato, 1998; Field and Garland, 2003). Based on the Occupational Therapy Practice Framework, 2nd .edition (Occupational Therapy Practice Framework (OTPF-2); 2008), "eating is defined as the ability to keep and manipulate food or fluid in the mouth and swallow it." In children with an ASD, problems can include physical difficulty in bringing food to the mouth, motor and sensory deficits in and around the mouth, and behaviorally based eating problems.

Oral motor impairments may impact feeding and eating which can lead to difficulty in using a cup and/or a straw and/or managing foods and liquids in an individual's mouth. Assessment of oral motor and fine motor skills may provide helpful information to create and guide interventions for children suffering with an ASD.

Section Six: Food Selectivity

Food Selectivity and How It Impacts Children with an ASD

Levin et al. characterized food selectivity as a diet that is limited in a variety of food items and that individuals reject novel foods when offered (Levin et al., 2001). Although picky eating is not uncommon in young children, it appears that children with an ASD may be more selective and it may extend past childhood. There is limited empirical evidence that supports food selectivity as being a problem in children with an ASD (Williams K. et al., 2005; Williams P, 2000; Schreck, 2004). Furthermore, food selectivity was not operationally defined until 2010 by Bandini and colleagues; therefore, food selectivity was not consistently measured prior to 2010.

Ahearn and colleagues were interested in determining if food selectivity was a concern in children with an ASD. Ahearn and colleagues included 30 children with an ASD or PDD-NOS, aged three to 14 years in the study (Ahearn et al., 2001). Each participant was exposed to six presentations of four different food items (24 trials/session), one at a time, on a plastic spoon, that took place during six different sessions. Food acceptance, food expulsion, and disruptive behaviors were all recorded. Analysis of the results illustrated three patterns: food acceptance, complete food refusal, and food selectivity based on type of food and texture. More than half (57%, n=17 out of 30) of the participants exhibited low levels of food acceptance

(Ahearn et al., 2001). Ahearn and colleagues suggested that food sensitivities caused by sensory preferences and difficulty with motor control may lead to higher rates of food selectivity, restriction, and limited textures (Ahearn et al., 2001). This study evaluated direct measures of food intake, but failed to define “food selectivity”; and they did not have a control group, which limits the generalizability.

Schreck and colleagues compared food selectivity in 138 children with an ASD to 298 children who were typically developing and who were between the ages of seven and nine-and-a-half years (Schreck et al., 2004). Primary caregivers were instructed to complete questionnaires pertaining to their family’s eating habits. Results illustrated that children with an ASD refused more foods (p<.000), required food to be presented in a particular way (p<.000), and consumed less of a variety of foods (p<.000) compared to the typically developing children. A methodological shortcoming was the measures used to determine dietary intake in the two groups of children. The questionnaire used to examine food intake was designed by the authors and was not a validated measurement tool for food selectivity in children with an ASD (Schreck et al., 2004).

In 2005, Williams, Gibbons and Schreck conducted a retrospective review with its primary focus on food selectivity (Williams et al., 2005). They attempted to determine the differences in food selection and variety consumed between typically developing children and children with ASD. One hundred and seventy eight children, aged 24-149 months, were divided into three groups. The first group consisted of children with an ASD. The second group included children with special needs but not ASD, and the last group consisted of typically developing children. Primary caregivers completed a comprehensive medical questionnaire prior to the initial clinic appointment which included a 145-item food frequency questionnaire and a three-day food record. An initial interview was conducted to confirm the caregivers' responses. Chi- square analyses were conducted to investigate whether children with an ASD and typically developing children differed in food selection and in the variety of food each group consumed. Results indicated that children with an ASD were significantly different on insisting that the same utensils or dishes were used during every meal when compared to the other groups (p=.02). Also, children with an ASD insisted that food was prepared a specific way significantly more than the two other groups (p=.03). There were no significant differences between the three groups regarding food variety. However, there was a general trend suggesting that children with an ASD were more selective and appeared to follow a similar pattern reported in previous studies (Williams et al., 2005). The primary limitation was that the researchers did not use a reliable and valid instrument to assess food intake and behaviors for children with ASD. Also these assessments were based primarily on caregiver self-reporting, which makes it difficult to generalize the findings.

According to Bandini et al., previous research defined food selectivity based on parental report and not direct measures of food intake (Bandini et al., 2010). In 2010, they operationalized the definition of food selectivity into three domains: food refusal, limited food repertoire, and high single frequency food intake. Food refusal was based on the number of foods that their child would not consume as well as the percentage of foods the child would not eat relative to the foods that were offered. The high frequency single food intake domain was determined if a child consumed a food item four or more times during a day. Limited food repertoire was defined as how many unique foods each child consumed. If a child experienced any one of the three domains, they were considered to be food selective (Bandini et al., 2010). In their study they included 53 children with an ASD and 58 children who were typically developing, three to 11 years of age. Primary caretakers were interviewed regarding their child's dietary intake habits and use of special dietary interventions, and they were required to complete a demographic/medical questionnaire along with recording everything their child consumed, including beverages, for three consecutive days. Their results illustrated that children with an ASD were more likely to refuse foods compared to the typically developing children (p<.001). Of interest is that high frequency of single food intake was rarely seen in either group (p=.19), and it did not appear that children "outgrew" food selectivity as was believed by researchers. There were a number of limitations in this study. One was that the definition of high frequency single food intake didn't identify the participants who ate the same foods for all three meals, since they determined four or more foods would be considered high frequency. Another limitation was that food refusal and high frequency single food intake was based on a modified food frequency questionnaire that was completed by the primary caretaker. Also, parents may not have offered foods that were likely to be refused by the child, therefore influencing the food refusal domain results. Bandini and colleagues definition of food selectivity will be used to identify participants as food selective in this study.

Another more recent study conducted by Zimmer and colleagues (2012) enrolled 22 children with an ASD and compared them to 22 age-matched children who were typically developing. This study attempted to determine the frequency of food selectivity along with comparing nutritional intake between the two groups. Dietary intake and nutritional status were measured by calculating body mass index (BMI) and analyzing a food frequency questionnaire. The researchers assigned a food variety score. A low food variety score was defined as having a score one standard deviation or more below the mean in the typically developing group. Children with an ASD consumed a mean of 33.5 (SD± 12.6) foods per month compared to the control group who tried a mean of 54.5 (SD± 18.9), p <.001 (Zimmer and Hart 2012). Children with an ASD who were food selective are at an increased risk for inadequate intakes of calcium (p<.001), vitamin A (p<.02), vitamin B12 (p=.01), vitamin D (p<.001), and protein (p =.01). Food variety was significantly lower in children with an ASD when compared to the typically developing children. The researchers concluded that it is important to better understand the implications of food selectivity in children with an ASD in order to improve nutritional status (Zimmer et al, 2012).

Section Seven: Investigating Obesity as it Relates to ASD

Definition and Prevalence of Pediatric Overweight and Obesity

It is well known that obesity has dramatically increased over the past 20 years and is considered an “epidemic” and a “public health crisis” and can affect all children (Ogden et al., 2008). The prevalence of childhood obesity has tripled over the past two decades and has been estimated to affect approximately 8.4%-20.5% of U.S. children, ages two to 19 years, and the prevalence of overweight in children is approximately 34.5% (Ogden et al., 2014). Disparities among race, gender, age, geographic region and socioeconomic status exist (Wen et al., 2012). It appears 29% of White girls are overweight/obese compared to 36% of African American and 37% in Hispanic girls (Ogden et al., 2014). Approximately, 40% of Hispanic boys are overweight/obese compared to 34% of African American and 28% of White boys (Ogden et al., 2014). According to Curtin and colleagues, the prevalence of obesity in children with an ASD was 30.4% compared to 24% in typically developing children (Curtin et al., 2010). Overweight has been defined in children as having a Body Mass Index (BMI) $\geq$ 95th percentile and obesity is $\geq$ 99th percentile. Risk factors associated with childhood obesity are increased risk of type 2 diabetes, cardiovascular disease, orthopedic problems, sleep apnea, and menstrual irregularities in females.

Overweight and Obesity in Children with an ASD

Childhood obesity is a serious health issue in the United States; but despite the growing evidence of obesity in children, there is minimal research that has examined this problem in children with developmental disorders, especially children with an ASD. There is a small amount of evidence suggesting that children with an ASD may be at a greater risk of obesity when compared to typically developing children. It has been hypothesized that this may be due to the limited variety and consumption of fruits, vegetables, lean meats and low-fat dairy products that children with an ASD consume (Curtin C, 2010, 2005).

A study by Chen et al. used the 2003 National Survey of Children’s Health (NSCH) in order to determine the prevalence of obesity among children with chronic conditions (Chen et al., 2010). The NSCH is a random-digit dial population-based household land line telephone survey sponsored by the Maternal and Child Health Bureau and conducted by the National Center for Health Statistics at the Centers for Disease Control and Prevention (van Dyck P, K. M., et al., 2004). The study included 46,707 children between the ages of ten and 17. They determined that the prevalence of obesity among all children was 14.8%, and the adjusted prevalence of obesity in children with an ASD was 23.4%. The results showed that children with an ASD had the highest adjusted prevalence of obesity when compared to children with learning disabilities, speech problems, physical impairments, and developmental disabilities other than an ASD. Because of the cross-sectional nature of the NCHS data, inferences about causal relationships between chronic conditions and childhood obesity cannot be made. Another limitation is that they included only older children and adolescents; therefore, the results cannot be generalized to younger children with an ASD. Lastly, BMI data were not measured; rather it was parent reported, which may not have been accurate.

Another study using the NCHS 2003 survey was done by Curtin et al., who conducted a secondary data analyses (Curtin et al., 2010). The purpose of this study was to determine the prevalence of obesity in children with an ASD by comparing them to typically developing children (Curtin et al., 2010). Out of the 85,272 children between the ages of three and 17 years, 454 children had an ASD. Obesity was defined as a BMI of ≥ 95th percentile for age and sex of a child (Curtin et al., 2010). The results showed that 30.4% of children with an ASD were more likely to be obese compared to 23.6% of typically developing children (p=.05). The secondary data analyses cannot determine risk factors, but the authors suggested that the unusual eating habits of children with an ASD may contribute to the development of obesity. The authors acknowledged that a diagnosis of an ASD was not confirmed, and the fact that the BMI was also reported by the parent was a limitation in the current study. Another limitation was that the ASD group of children was small so the researchers were not able to separate them by sex and age of the child (Curtin et al., 2010).

The most recent study conducted by Evans and colleagues looked at BMI status and dietary intake patterns in 53 children with an ASD and 58 typically developing children, ages three to 11 (Evans et al., 2012). Participants were recruited from the Children's Activity and Meal Pattern Study (CHAMPS), which was designed to identify dietary patterns and overweight and obesity risk factors in children with an ASD. Parents were interviewed and were asked to complete several questionnaires along with a food frequency questionnaire. The results did not illustrate significant differences in BMI z-scores (underweight <5th percentile, overweight ≥ 85th percentile, ≥ 95th percentile obesity). Even though the BMI results between the two groups were not significantly different, children with an ASD consumed more juice, sweetened non-dairy beverages, energy dense snacks, and less fruits and vegetables ($p<.05$) (Evans et al., 2012). There were several limitations in this study, data were cross-sectional and from a small sample size; therefore, results cannot be generalized and associations between dietary patterns and weight status cannot be made.

Obesity has increased over the past two decades in children in the United States (Ogden et al., 2008) and it has been reported that children with an ASD have similar or even higher rates of overweight and obesity when compared to other children (Curtin et al. 2005). Assessing weight status and growth alone (Newschaffer, 2007; Curtin et al., 2005; Bolte et al., 2002) can overestimate nutritional adequacy in children with food selectivity and other problematic eating behaviors. Additional dietary factors need to be evaluated, because weight alone may not reflect nutritional status. Epidemiological data have shown that consuming energy dense foods correlates to weight status in U.S. adults; however, additional studies are warranted in the pediatric population. Adults who regularly consume the recommended amounts of fruit and vegetables have lower body weight, which supports the need to better understand food selectivity in children with an ASD and how it correlates to weight status long term.

Section Eight: Summary and Conclusion

Few studies have examined food selectivity in children with an ASD and how it impacts nutritional status. Previous research has been limiting due to small sample sizes, parental reports, different methodology in measuring food intake, and generalizability. The proposed study will examine the relationship of food selectivity and weight status in children with an ASD, other developmental disorders (NIC), and typically developing (TD) children, ages two to six years old using existing sets of SEED data. Food selectivity in children with an ASD has not been rigorously studied, and what is available consists of a small number of participants. This study will be the first to include more than 400 participants and have three comparison groups. It will also be the first study to examine BMI status as it relates to food selectivity.

Chapter 3

Study Hypotheses, Research Methods, And Analysis Plan

Overall Research Objectives

The overall objectives of this study were: (1) to investigate nutrient adequacy of diets of children with an ASD and compare them to age-matched children with other developmental disabilities (NIC) and to children who were typically developing (TD); and (2) to examine the relationship of food selectivity to nutritional and weight status in three groups of children (ASD, NIC, TD) ages two to six years old.

Specific Aims and Hypotheses

Specific Aim 1: Analyze macro- and micronutrient intakes and commonly consumed foods of children with an ASD, children with other developmental disabilities (NIC), and children who are typically developing (TD).

Hypothesis 1: Macronutrient intakes will not differ among the three groups (ASD, NIC, TD).

Hypothesis 2: Micronutrient intake distributions will differ among the three groups.

2a: Children with an ASD will have diets that are lower in calcium, vitamin D, iron, zinc, and vitamin B12 compared to NIC, and TD groups.

2b: Children with an ASD will have diets that are higher in Mg, folic acid, and niacin compared to NIC and TD groups.

Specific Aim 2: To compare weight status, analyzing BMIz scores, among the three groups of children (ASD, NIC, and TD). To estimate the prevalence of growth faltering (sex- and age-defined BMI less than or equal to the fifth percentile), overweight (overweight is defined as the sex- and age-defined BMI greater than or equal to the 85th percentile and less than the 95th percentile of the CDC BMI growth charts), and obesity (sex- and age-defined BMI greater than the 95th percentile) among the three groups.

Hypothesis 3: Children with an ASD have a higher prevalence of overweight and obesity compared to the NIC and TD groups.

Hypothesis 4: Children with an ASD will have an equal prevalence of growth faltering when compared to the NIC and TD groups.

Specific Aim 3: To determine the prevalence of food selectivity in children with an ASD, in the NIC and the TD groups. To investigate the relationship between food selectivity and dietary intake and weight status between the three groups.

Hypothesis 5: Children with an ASD will exhibit a higher prevalence of food selectivity compared to the NIC and TD groups.

Hypothesis 6: Children with an ASD who are food selective will be more likely to have nutritional deficiencies compared to children who are not classified as food selective.

Hypothesis 7: Children with an ASD who are food selective will exhibit a higher energy intake and prevalence of overweight and obesity when compared to children who are not food selective.

Research Design

This study utilized a cross-sectional case control design. This study analyzed data that were collected for the Study to Explore Early Development (SEED) which was a collaborative epidemiologic study to identify risk factors for an ASD. This design was suggested because the data have already been collected, and the case control study design is often used to identify factors that may contribute to medical conditions which compare subjects who have the condition to those who do not. Three day food records were completed for all participants and are frequently used in research and clinical practice (Falciglia et al., 2009). Weight and height measurements were used to calculate Body Mass Index (BMI). Body Mass Index (BMI) is a way to evaluate body weight and expresses the ratio of a person's weight to the square of their height (Kleinman, 2008). It accurately predicts health risk associated with underweight, overweight and obesity. BMI values below 18.5 or above 30 have increased risks of health problems (CDC, 2014).

General Description of the Original SEED Study

The overall purpose of the original SEED study was to investigate risk factors for ASD and phenotypic subgroups of ASD using a population-based, case-control study design. There were six study areas (California, Colorado, Maryland, North Carolina, Pennsylvania, and Georgia) that implemented the collaborative research protocol, and common data elements were combined from the study sites for analysis. The study participants included children born in and residing in the six study areas: the San Francisco Bay area, Denver metropolitan area, Philadelphia metropolitan area, Maryland, central North Carolina, and the Atlanta metropolitan area. Cohort children who were identified with an ASD were to be compared to a sample of children identified as NIC, as well as a random sample of TD children.

Current Study Population Description

This is a cross sectional case control study which utilized data from the Colorado Department of Public Health and Environment Center for Autism and Developmental Disabilities Research and Epidemiology (CADDRE) SEED database. No additional data were collected for these analyses since all necessary data were available to complete this study. Approval by the Institutional Review Board for the purpose to analyze the CO data for dietary intake, BMI, and demographics occurred through Colorado State University on June 11, 2011 (See Appendix F). Only, Colorado data were analyzed for this study. The Colorado cohort consisted of children with an ASD, NIC, and children who were TD. The Colorado cohort included children who were born from September 2003 through August 2007. Every participant resided in the Denver Metropolitan catchment area in Colorado.

Current Sample Size

The final cohort for Colorado consisted of 403 children. There were 113 children with an ASD, 143 NIC, and 147 TD children.

Inclusion Criteria

The original sample consisted of children with an ASD, NIC, or who were TD. Children with an ASD included Autistic Disorder, Pervasive Developmental Disorder-Not Otherwise Specified, and Asperger’s Syndrome. Children in the NIC were diagnosed with intellectual disabilities (e.g., Down’s Syndrome) other than an ASD. The typically developing children did not have developmental concerns and appropriate growth and development were present. The study cohort also included both parents of each enrolled child. Children were included if they were: (1) between 24–60 months of age at time of eligibility (birth date range of September 2003 to August 2007); (2) if they were between 30–68 months at completion of the child’s clinical developmental evaluation; (3) if they were born in and lived in the study catchment area; (4) and if a child lived with a knowledgeable caregiver. For the purposes of this study participants were included if the parents successfully completed a three day food record and if the participants' weight and height were available.

Exclusion Criteria

Children who do not meet all of the inclusion criteria were not eligible to participate in the original study. In the original SEED study, children were excluded from the study if: (1) Not born in and resided in study catchment area; (2) Not in birth cohort (determined by birth date); (3) No knowledgeable caregiver was available; (4) No English or Spanish speaking caregiver; (5) Legal consent was not obtainable; (6) Age greater than 60 months or less than 24 months. Siblings (other than twins or multiples) of a child already enrolled were not eligible to participate in the original study. Participants for this study were excluded if the caregivers did not successfully complete the three day food record and if height and weight measurements were not available.

Recruitment

Recruitment for the original CO SEED study began in December 2007 and ended April 2011. ASD and NIC children were identified through several sources serving or evaluating children with developmental problems. Potential participants who received services through a local Community Center Board (CCB), JFK partners, the Child's Development Unit at the Colorado Children's Hospital, or through a random mailing of the general population through vital records at the health department were considered eligible to participate in the SEED study. Eligible participants lived in Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson counties. In Colorado, potential ASD and NIC children were sent a letter from the source (on their letterhead) with the SEED Introductory letter and a postage-paid response card addressed to SEED. The source letter stated that none of the family's personal information was provided to SEED; however, if the caregiver was interested in obtaining more information, they would need to send the response card to the CO SEED Study Coordinator. In order to determine final ASD status (i.e., confirmed cases), a clinical evaluation using standardized developmental measures was conducted as part of the enrollment process of the study. After the primary caregivers contacted the CO SEED coordinator, they were screened for eligibility, and if they met the qualifications, then they were enrolled. The typically developing children were identified from birth certificates on the basis of birth date range and residence in the catchment area at the time of birth.

Enrollment into the original CO SEED Study

Enrollment contact with study participants consisted of a mailed invitation packet, a mailed enrollment packet, follow-up phone calls/contact, and questionnaire packets. If a response card was not received back within six weeks, a second letter of invitation was sent to potential CO participants. If there was no response a second time, a final letter of invitation was mailed approximately six months later. Families were not contacted more than three times. If a potential participant returned a response card indicating an interest in the study, staff would make up to nine telephone calls. If the potential participant was not reached after nine attempts, they were not contacted again. If the potential participant was reached by telephone, a verbal screening took place. If the caregiver agreed to participate, then an enrollment packet was mailed to potential participants. The enrollment packet had detailed information regarding the study and procedures. Study staff contacted potential participants via telephone no sooner than seven days after the Enrollment Packet was sent through postal mail.

Once again up to nine attempts were made by the study staff to contact participants via telephone at various times during the day and on different days during the week. If they were unable to be reached after nine attempts, then a letter was sent indicating that they would be dropped from the study unless they contacted the study staff to continue.

Consent Process

The consent process for the original study was a multi-step process and was collected on five separate occasions. The study personnel obtained both verbal and written consents from all participants. The study personnel were required to complete a with Colorado Multiple Institutional Review Board (COMIRB) 101 class in order to be able to conduct human. The study personnel were trained to answer questions, explain the purpose of the study and document the consent process. First, verbal consent to conduct an ASD screen and to participate in the study was obtained through a telephone call after the individual had received the invitation letter. The Social Communication Questionnaire (SCQ) was administered during the initial phone call to all participants (potential ASD, NIC, and TD). Second, there was an Enrollment Packet which included written consent forms for: a.) Medical records abstraction (through the HIPAA medical records release authorization) and b.) Buccal swabs collection. Third, verbal consent for the caregiver interview was obtained during the interview phone call. Fourth, study staff obtained written or oral consent for the Questionnaire Packets I and II. Fifth, during the first face-to-face clinic visit, study staff obtained informed consent for the overall study.

Methodology

Procedures for the Original CO SEED Study

Colorado participants received three day food record training as part of their clinical visit at JFK Partners or at the Colorado Children's Hospital or during a home visit by study personnel. At the conclusion of the three day food record training, a start date was scheduled in order for the study personnel to keep track of the participants who were actively completing the three day food record. During the second day of completing the three day food record, study personnel called each participant to answer questions, address concerns, and to confirm that the three day food record had been started. Once the completed, three day food records were received by the study personnel, the three day food records were immediately reviewed for completion and ambiguities. Follow up calls were made if the three day food records were incomplete or to clarify ambiguous entries and the calls were made the same day the records were received.

Procedures for follow-up telephone calls for the three day food records

Follow-up telephone calls occurred during different times of the day (two morning, two afternoon, two early evening, two weekends). After eight unsuccessful attempts to contact the participant, a follow-up letter was sent and a reply was requested to determine if they were still interested in participating in the study. After two weeks, no more attempts were made to clarify the three day food records, and they were considered inactive unless the participants directly contacted the study personnel.

Original Data-Checking Procedures for the SEED Study

Questionnaires were reviewed by study personnel for completeness and legibility. Height and weight was collected at Children's Hospital Colorado by a combination of CO SEED staff, Pediatric Research Assistants (PRA), and Project personnel). Height and weight data were checked by the study personnel 3% of the time. Three day food records were first checked by the CO SEED staff, the first five records, and 5% thereafter were reviewed by a registered dietitian working with the study. When there was missing information in the three day food records, study personnel would look at the NDSR manual to define and obtain appropriate food substitutions. If three day food records were received and some of the information needed clarification, follow-up phone calls would be made within 24–48 hours.

Original SEED Measurements

The original study consisted of six main components: 1) primary caregiver telephone interview; 2) medical record abstraction; 3) primary caregiver completed self-administered questionnaires; 4) child developmental evaluation; 5) child dysmorphology exam; and 6) bio sampling from biological parents and child.

Primary measurement instrument

The measurement instruments that were used in this study were the three day food record, and demographic variables from the dysmorphology and anthropometrics documents used in the study. All questionnaires were developed by the original SEED study staff.

Three Day Food Record**:** The three day food record is a commonly used measure to assess dietary intake in clinical practice and research (Lanigan, 2004). Ziegler et al.

found that families of children with an ASD were more successful in completing the three day food record when compared to a 24-hour recall (Zeigler, 2006). The three day food record allows study participants to be trained, and to use measuring tools and visual aids in order to improve accuracy. The three day food record does not rely on memory, and participants can plan meals in advance that will improve accuracy in recording the amount of food that their child has consumed. The three day food record approach has been found to have fewer errors and to be more representative of actual dietary intake when compared to a five-day food frequency and a 24-hour recall in adults (Crawford, et al. 1994). Herndon et al. found that a three day food record was as accurate as a seven day food record for children with ASD (Herndon et al. 2009). All enrolled participants received training materials for the three day food record which included photographs that assisted in estimating portion sizes, an example of a correct and an incorrect three day food record, and a list of approved abbreviations. It also included instructions to write down all ingredients, brand names, any specialty food items, fortifications, and quantity of food items consumed by the participant. The three day food record consisted of two week days and at least one weekend day (e.g., Thursday, Friday, and Saturday) and the participants were instructed to complete them in consecutive days. The three day food record was created as a Microsoft Word document for the participants. Participants were asked to enter all food and beverages that their child consumed during two weekdays and one weekend day.

Body Mass Index (BMI): The participant's height and weight were measured at the initial visit by the registered dietitian or registered pediatric nurse. The child was measured without shoes or a coat two times, and if the measurements were not within 1 cm or 0.1 kg, the participant was measured a third time, (BMI was calculated in kilogram/meters^2) and the data were entered into the database for this study as BMI, BMI percentile, and BMI z-score for age and gender. BMI is the preferred means of monitoring children's growth (Kleinman, 2008) especially for research purposes since it is quick, easy and inexpensive. A BMI z-score will accurately illustrate how many standard deviations a BMI measurement is from the mean and will allow a participant to be categorized as underweight, normal weight, overweight or obese. BMI z-scores indicate how many units (standard deviations) a child’s BMI is above or below the average BMI value for their age group and sex (World Health Organization, 2004)

<u>Dysmorphology/Anthropometric Questionnaire:</u> In previous studies, sociodemographic variables have been associated with food choice and availability in the general population (Vernarelli et al. 2011; FAO 2009). These variables may affect the types of dietary interventions families choose for their child with ASD. It is not established whether families with higher educational attainment and higher socioeconomic status are more likely to use complementary and alternative medical practices, including supplements (Kemper et al. 2008). Demographic information (maternal educational level, family income by category, race, sex of the participant, and age of the participant) was requested of families as potential effect modifiers.

Training and Quality Control Methods for Data Collection

Training

A standardized training protocol and instruction manual provided general training to all study personnel. An oral presentation by the senior investigator was done to describe the background, purpose and approach for the study. Discussions for conducting field work, data security, safeguards for protecting privacy and confidentiality of personal information were conducted. The Study personnel were required to complete additional training, if necessary, to complete their responsibilities for the study.

Quality Control Methods

Study personnel who were responsible for entering the three day food records were required to have a minimum of a Bachelor's of Science degree in Nutrition. Initial quality control measures were done with ten standardized three day food records. Initial statistical validation of the ten standardized three day food records were calculated for total energy, carbohydrate, protein, dietary fiber, calcium, phosphorus, iron, zinc and sodium intake. Inter rater reliability was assessed by comparing the study personnel who were responsible for entering the three-day food records to two members from the Clinical Translational Research Center of The Colorado Children's Hospital. Quality control measures were performed for the first five three day food records in addition to every 20th three-day food record. An inter rater reliability score of $r = \underline{>} .85$ was determined to be acceptable for this study.

Data Cleaning and Record Keeping

During the original SEED data collection period, the Data Coordinating Center (DCC) coordinated information and maintained a database for all participating study sites that performed data analyses. The DCC organized the demographic variables necessary for the completion of this study. In addition, the DCC created a series of standard core recoded and new variables based on information provided by the SEED investigators from different data sources (i.e., maternal interview and maternal medical records) as well as developing summary variables so participating sites could use them.

The DCC was also responsible for the development of a centrally installed CADDRE Information System (CIS) to assist in tracking participants, schedule clinic visits, and to manage data entry.

Data Analyses

After the three day food record was reviewed, the three day food record, with an identification number, was entered into Nutrition Data System for Research (NDSR) for nutrient analysis by study personnel. The NDSR software was used for the nutritional analysis of every three day food record. This was the most accurate and comprehensive nutrient calculator software available designed for clinical research and epidemiologic studies. It was developed and maintained by the Nutrition Coordinating Center (NCC) at the University of Minnesota. (Schakel et al. 2001; 1997; 1988) The NCC is designated a Nutrition Research Resource by the National Institutes of Health. The database is updated every year to reflect marketplace changes with food labels and ingredients in food items sold. The NDSR uses Dietary guidelines by the Food and Nutrition Board of the Institute of Medicine (IOM) to analyze three day food records.

Macro-and micronutrients of interest from the three day food record, without supplements, were analyzed. Dietary guidelines (Estimated Average Requirements, Adequate Intakes, Upper Limits) suggested by the Food and Nutrition Board of the IOM were used to analyze the participant’s nutrient intakes (IOM 2000). The nutrients of interest in this study that have an Estimated Average Requirement (EAR) are niacin, folic acid, magnesium, iron, and zinc. Calcium and vitamin D do not have an EAR value; therefore, an Adequate Intake (AI) value was used to assess dietary intake. The EAR cut-point method is a probability approach that can be applied to nutrients with an

EAR, a Recommended Daily Allowance (RDA), and a symmetrical requirement distribution. The proportion of the population with intakes below the EAR represents an estimate of the proportion of the group with inadequate intakes. The recommendation for population research on nutritional sufficiency is to use the EAR and, when an EAR is not available, Adequate Intake (AI); the recommended average nutrient intake (Barr et al. 2002)was used. Figure 1. below from the Institute of Medicine (2004, p.23) illustrates the relationship of EAR, RDA, and Upper Limit (UL).

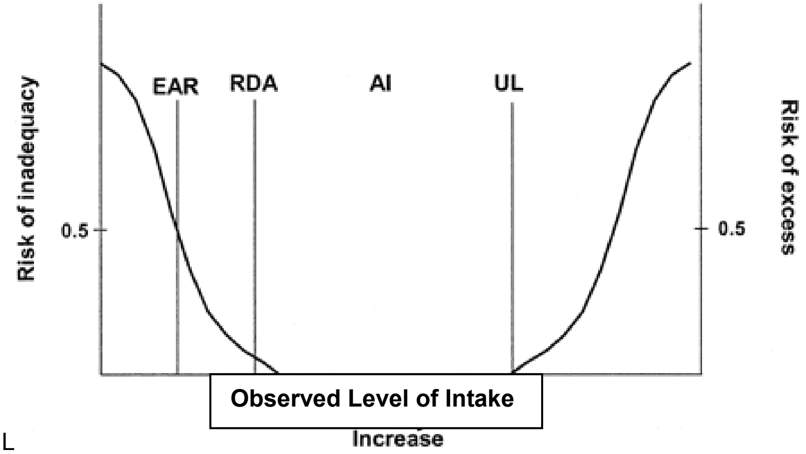

Figure 1. EAR, RDA,AI, UL

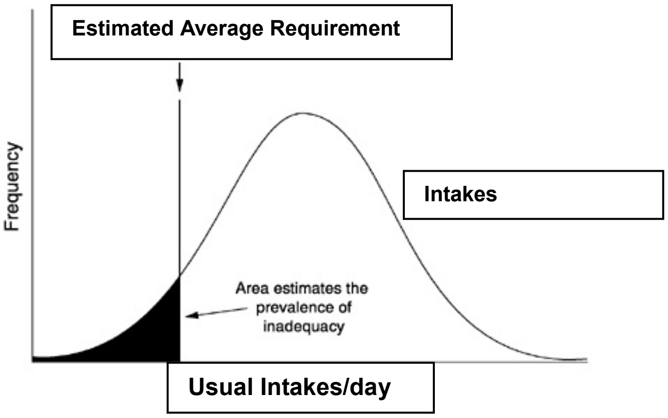

Figure 2. EAR

Figure 2. Illustrates the relationship of average intakes of a nutrient and the EAR. The bell shaped curve illustrates that the average intake was in excess of Estimated Average Requirement or of Adequate Intake (IOM 2000, page 428).

An Adequate Intake is an estimate of nutrient intake of a healthy group of people and is used when an RDA cannot be determined. Intakes around or above the AI are not likely to produce deficiencies of that particular nutrient.

For nutrients with an EAR, the probability of intake being less than the EAR was determined. Individuals with mean intakes at or above the AI were considered as having an adequate diet in that particular nutrient. The proportion of individuals whose usual intake exceeds the Upper Limits (UL) for nutrients of interest were also determined. This analysis was done for nutrients for which NDSR provided data in the units consistent with those established by the IOM.

Nutrient intakes across the three comparison groups (ASD, NIC, TD) were assessed and whether food selectivity was related to nutrient intake and weight status. Descriptive statistics were conducted for the demographic covariates: maternal education, maternal age, race/ethnicity, household income, child's sex, and prior diagnosis. For each hypothesis, descriptive statistics were conducted (mean, median, and standard deviations) in order to gain a better understanding of the variables of interest and the relationship between the variables of interest prior to formal analysis. Chi-square tests were conducted to determine if there were statistical differences among the demographic variables. In order to identify participants as food selective, Bandini and colleagues' definition of food selectivity was used to determine food selectivity by using the Limited food repertoire domain ($\leq$ 22 food items consumed over a three day period) and high frequency single food intake (HFSFI) domain (single foods eaten $\geq$ 4 times daily) was assessed to determine if a participant was food selective. If a participant was considered to have a limited food repertoire or HFSFI, then they were classified as food selective.

Specific Aim 1: Analyze macro- and micronutrient intakes and commonly consumed foods of children with an ASD, children with other developmental disabilities (NIC), and children who are typically developing (TD).

Means and standard deviations were calculated for total kilocalorie, total carbohydrate, total protein, total fat, calcium, vitamin D, iron, zinc, vitamin B12, magnesium, niacin, and folic acid dietary intake for all participants. Age- and sex-specific U.S. Dietary Reference Intakes (DRI) Recommended Dietary Allowance (RDA) values were used to determine nutrition adequacy in the three groups of children. Data were further tested using a one-way Analysis of Covariance (ANCOVA) for each variable comparing children with an ASD to NIC and to children who were TD and controlling for the confounding variables (maternal education, maternal age, race/ethnicity, household income, child sex, prior diagnosis). A post hoc Fisher's protected t-test was done if the ANCOVA was significant ($p < 0.05$) among the ASD, NIC, TD in order to control for type 1 error and to determine if there was significance between the groups.

	Dependent Variables	**Groups**	**Tests**
Hypothesis 1	Total energy, fat, protein, carbohydrates	ASD, NIC, TD	One-way ANCOVA
Hypothesis 2	Calcium, vitamin D, iron, zinc, vitamin B12, magnesium, folic acid, niacin	ASD, NIC, TD	One-way ANCOVA

Specific Aim 2: BMIz scores were used to compare weight status among the three groups of (ASD, NIC, and TD). The Center for Disease Control (CDC) gender specific BMI growth charts were used to estimate the prevalence of growth faltering sex- and age BMI less than or equal to the fifth percentile), overweight (sex- and age-defined BMI greater than or equal to the 85th percentile and less than the 95th) and obesity (sex- and age-defined BMI greater than the 95th percentile) and these classifications were determined for the three groups.

Means and standard deviations for BMIz scores were calculated and used to compare group height and weight data. A one-way ANCOVA was done to further analyze the BMI dataset controlling for covariates (sex, race, ethnicity, age of child, maternal education, income level, total kilocalorie).

	Dependent Variables	**Groups**	**Tests**
Hypothesis 3	BMI	ASD, NIC, TD	One-way ANCOVA
Hypothesis 4	BMI	ASD, NIC, TD	One-way ANCOVA

Specific Aim 3: To determine the prevalence of food selectivity in children with an ASD, children with other developmental disabilities, and children who were typically developing. To investigate the relations between food selectivity and 1) nutrient density; and 2) weight status in the 3 groups. Logitistic transformations were done with binary data which is commonly done (Raymond et al. 2010, Myers, R.H and Montgomery, D.C. 2002). Logit transformation and a generalized linear model (ANCOVA) adjusted for possible covariate differences among the groups. ANCOVA analyses were conducted since ANCOVA's include a mixture of categorical data, including binary data, and quantitative variables (Myers, R.H., Montgomery, D.C. 2002).

	Dependent Variables	Groups	Tests
Hypothesis 5	Number of foods eaten, HFSFI	ASD, NIC, TD	One-way ANCOVA
Hypothesis 6	Number of foods eaten, HFSFI, macro and micronutrients of interest	ASD who are food selective, ASD, NIC, TD who are not food selective	One-way ANCOVA
Hypothesis 7	BMI and energy intake	ASD who are food selective, ASD, NIC, TD who are not food selective	One-way ANCOVA

Outcome variables: height, weight, total kilocalories, total fat, total protein, total fiber, calcium, vitamin D, iron, zinc, vitamin B12, magnesium, folic acid, niacin, BMI scores, limited food repertoire, HFSFI, food selectivity

Independent variable for hypotheses 1-5: group (ASD, NIC, TD)

Independent variable for hypothesis 6-7: group (ASD who are food selective and ASD, NIC, TD who are not food selective) and ASD who are food selective

Covariates

- Sex (Dichotomous: Male, Female)
- Race (Categorical: Caucasian, African American, American Indian, Asian or Pacific Islander)
- Ethnicity of Child (Dichotomous: Hispanic, non-Hispanic)
- Age of Child (Categorical: 0-2y, 3y, 4y, 5y)
- Maternal Education (Categorical: some college/trade, high school education, bachelor's degree, advanced degree)
- Income Level (Categorical: 1=< $10,000, 2=$10,000-$30,000, 3=$30,000-$50,000, 4=$50,000-$70,000, 5=$70,000-$90,000, 6=$90,000-$110,000, 7= >$110,000, 0= missing)
- Total Kilocalories (Continuous)

Chapter 4

Results

Participants

Demographic variables are presented in Appendix A, Table 4-6. A total of 403 participants completed the three day food records, and 347 participants' weight and height measurements were obtained in order to calculate body mass index (BMI) scores. The ratio of males to females was approximately two-and-a-half times more males, which was expected and reflected in other ASD studies as males are five times more likely to be diagnosed with an ASD than females (CDC 2014). Ethnicity of the study sample is representative of Colorado population, 68% of the participants' maternal race was White (Source U.S. Census Bureau, 2012). There was no significant difference in age among the groups, and 73% of the participants were between the ages of four and five years old. With regard to maternal education, 36% of the mothers had a bachelor's degree and 19% had earned an advanced degree, and the median income was $50,000-$70,000. Overall, participants did not differ among groups for demographic characteristics, therefore making it a homogenous sample.

Dietary Analysis

Hypothesis 1: Macronutrient intake distributions will differ among the three groups (ASD, NIC, and TD).

Hypothesis 2: Micronutrient intake distributions will differ among the three groups. 2a: children with an ASD will have diets that are lower in calcium, vitamin D, iron, zinc, and vitamin B12 when compared to NIC and TD groups. 2b: children with an ASD will have diets that are higher in Mg, folic acid, and niacin when compared to NIC and TD groups.

The results (Table 7) indicated there were few significant differences in mean intakes of macro- and micronutrients among the three groups (ASD, NIC, TD). The ASD group (M=48.4g, SD= 14.3) consumed significantly less protein compared to the NIC (M=52.3g, SD= 15.4, p=.005) and TD (M= 53.2g, SD= 13.1, p=.001) groups and the ANCOVA showed (Table.8) a significant main effect for the group with an ASD (F (2,400)= 6.26, p=0.002) regarding protein intake. Overall, the total fat, total kilocalories, total fiber and total carbohydrate intakes among the three groups did not differ except that total kilocalorie intake was significantly different between girls and boys; boys consumed more kilocalories (p =.03). Overall, approximately 50% of children's fiber intake in the United States is below the recommended amounts. Fiber intake was below the EAR (19-25g/day) in all groups (ASD: M= 11.6, SD=5.1; NIC: M= 11.5, SD=5.0; TD: M=11.6, SD= 3.9) which appears to correlate with national norms.

The ASD group (M=7.0mg, SD= 2.7) consumed significantly less zinc when compared to the NIC (M= 7.8mg, SD= 2.7, p=.009) and TD (M= 7.6mg, SD= 2.7, p=.05) groups (Table.9-10) and the ANCOVA showed a significant main effect for the group with an ASD (F(2,400)= 3.59, p<0.03). In addition, the ASD group (M=370mcg, SD=182) consumed significantly less folic acid than the NIC group (M= 405.8, SD= 177.8) and the TD group (M= 430mcg, SD= 197, p=.007) and the ANCOVA showed a significant main effect for ASD (F(2,403)=3.80, p=0.02). Despite our hypothesis, the ASD group did not consume significantly more niacin, folic acid, and magnesium when compared to the NIC and TD groups (p>0.05) (Table. 9-10, 25).

Hypothesis 3: Children with an ASD will have a higher prevalence of overweight and obesity compared to the NIC and TD groups.

Hypothesis 4: Children with an ASD will not have a significant difference of growth faltering when compared to NIC and TD groups.

There were no significant differences in BMI z-scores or BMI percentile ranks among the groups (p>.05). Table 11-12 reports BMI status by percentiles among the ASD, NIC, and TD groups. There were no differences in the frequency of children falling $\leq$ 5th percentile , the 85th-95th percentile or the $\geq$ 95th percentile ranks among the three groups.

Hypothesis 5: Children with an ASD will exhibit a higher prevalence of food selectivity when compared to the NIC and TD groups.

Data were not normally distributed therefore logit transformations for HFSFI and Food Selectivity binary variables were conducted before the ANCOVA was performed. Table 13-14 presents the results from the number and percent of total foods eaten, HFSFI, and total counts for food selectivity among the three groups. A statistically significant difference was found among the ASD NIC, and TD groups regarding food selectivity, F (2,400) =4.80, p= 0.008 and HFSFI, F(2,400)= 3.85, p=0.02, and limited food repertoire, F (2,400)=15.73, p=0.0001. The ASD group was significantly more food selective (46%) when compared to NIC (31%) and TD (26%). Additional analysis illustrated that the number of foods consumed was significantly less in the ASD group (M= 24.5, SD=6.75) compared to the NIC (M=27.4, SD=5.9) and TD group (M= 29.0, SD= 5.65, p=.00). Table 15 presents a more detailed analysis of HFSFI among the groups. HFSFI was more prevalent in children with an ASD (M=.37, SD=.47) compared to NIC (M=.23, SD=.40, p=.04) and TD (M=.21, SD=.39, p =.02), p <.04. As hypothesized, the ASD group (M=.48, SD=.50) exhibited a higher prevalence of food selectivity compared to the NIC (M=.33, SD=.47, p=.04) and TD group (M=.26, SD=.44, p=.00) (Table. 16-17). Table 20 compares the mean number of servings for fruit, vegetables, fats/oil/sweets, grains, dairy and protein intake among the ASD, NIC, and TD groups. Children with an ASD consumed significantly fewer vegetables (ASD: 2.6; NIC: 3.1; TD:3.2), less fats (ASD: 7.85; NIC: 8.30; TD: 8.80), fewer grains (ASD: 4.18; NIC: 4.58; TD: 4.93), less total protein (ASD: 3.71; NIC: 4.10; TD: 4.25), and less dairy (ASD: 3.42; NIC: 4.02; TD: 4.60) when compared to the NIC group and TD group (all p values <.05). Overall, results illustrated that children with an ASD consume fewer servings of the food groups compared to NIC and TD children.

Hypothesis 6: Children with an ASD who are food selective will be more likely to have nutritional deficiencies compared to children who are not classified as food selective.

Children with an ASD who were food selective did not appear to have an increased risk of nutritional deficiencies when compared to ASD-NFS, NIC-NFS and TD-NFS groups (p>.05) as the majority of participants in each group met the EARs for the nutrients of interest. Inadequate intakes of calcium were found in ASD-FS (38%), ASD-NFS (43%), NIC-NFS (36%), and TD-NFS (28%); however, there were no differences in intakes among groups. Inadequate intakes of vitamin D (ASD-FS: 42%; ASD-NFS: 38%; NIC-NFS: 39%; TD-NFS: 35%) and fiber (ASD-FS:71%; ASD-NFS: 77%; NIC-NFS: 80%; TD-NFS: 67%) were seen in all groups, but there were no significant differences among the groups (Table 18-19).

Hypothesis 7: Children with an ASD who are food selective will exhibit a higher energy intake and prevalence of overweight and obesity when compared to children who are not food selective.

The ASD-FS consumed more total calories (M: 1457, SD: 461) when compared to ASD-NFS (M: 1327, SD: 313, p=.04), NIC-NFS (M: 1383, SD: 341, p=.04), and TD-NFS (M: 1400, SD: 273, p=.04). Correlations between food selectivity and prevalence of overweight and obesity were analyzed and illustrated in Table 21. There were no significant differences (p >.05) among the prevalence of overweight and obesity among ASD-FS compared to NFS participants. The results of this study suggest that in this sample ASD-FS children who were food selective (15%) had the same prevalence of overweight (BMI 85-95th percentile) as ASD-NFS (8%), NIC-NFS (15%) and TD-NFS (11%). Also, the results in Tables 22-24illustrated that obesity prevalence was the same in ASD-FS (2%), ASD-NFS (16%), NIC-NFS (8%), TD-NFS (2%)..

Chapter 5

Discussion

Few studies have been able to determine nutritional deficiencies and Body Mass Index (BMI) status in children with an Autism Spectrum Disorder (ASD) who are food selective. Nutritional deficiencies can lead to growth impairments, immune dysfunction, sleep disturbances, increased risk of infections, and mortality (Allen et al. 2006). The purpose of this study was: (1) to investigate nutrient adequacy of diets in children with an ASD and compare them to age matched (two to six years old) children who are typically developing (TD), and with children who have other developmental disabilities (NIC); and (2) to examine the relationship of food selectivity to nutritional and weight status among these three groups (ASD, NIC, TD).

This study employed a cross-sectional case control study design and analyzed data that were originally collected for the Study to Explore Early Development (SEED), a collaborative epidemiologic study to identify risk factors for an ASD. The participants' three day food records, along with height and weight data, were analyzed to address the study's specific aims.

Food Selectivity

Parents of children with an ASD often state that their child is a "picky eater" or avoids several types of food (Zimmer et al., 2012). Few studies are available that have determined prevalence of food selectivity in children with an ASD compared to NIC and TD children. To the best of my knowledge, there are no studies that have determined whether or not children with an ASD who are food selective are at an increased risk of nutritional deficiencies and an increased risk of overweight and obesity while comparing them to NIC and TD groups. In this study food selectivity is defined as a child consuming a limited food repertoire (≤ 22 different food items) and/or high-frequency single food intake (single food item eater ≥ 4 times/day) (Bandini et al., 2010).

Bandini et al., (2010) found that children with an ASD were more likely to be food selective when compared to the NIC and TD children (p <.05). Bandini and colleagues' sample size consisted of 53 children with an ASD compared to 58 typically developing children with an age range of three to 11 years old. Bandini and colleagues operationally defined food selectivity into three domains, all of which showed significant differences between the two groups (Food Refusal: ASD= 26%; TD= 18%; Limited Food Repertoire: ASD= 5%, TD= 4.6%; High Frequency Single Food Item= ASD: 7.6%; TD: 1.7%). Their results indicated that food selectivity was not dependent on age, but rather it was more common in children with an ASD when compared to typically developing children (p<.05). Researchers recognized the possible limitations of the HFSFI domain and that it may have excluded some children who should have been classified as food selective (Bandini et al., 2010). According to the HFSFI domain, a child with an ASD who consumes hot dogs for breakfast, lunch and dinner would not be food selective since they are not consuming hotdogs ≥ 4 foods/day; therefore, this definition is limiting and most likely excludes children with an ASD who are food selective. HFSFI was more common in children with an ASD (37%) compared to NIC (23%) and TD (21%) which was statistically significant. Results may be skewed due to the limitations of the HFSFI domain, however it is important to note that Bandini and colleagues' operationalized definition is the only one that is validated for research. Data from this study showed 30% of children with an ASD experience a more limited food repertoire (≤ 22 different food items) when compared to NIC (16%) and TD (12%), p<.05. Results from this study indicate that food selectivity is more common in children with an ASD, and that they have a more limited variety and consume HFSFI more than the NIC and TD children. In this study results most likely have under-reported food selectivity due to the HFSFI domain and if it is redefined as a single food eaten 3 or more times a day, then that would most likely capture everyone who is potentially at risk of being food selective. It is important to note that food selectivity was also more common in the NIC group when compared to the typically developing group (p<.05), suggesting that group may be at an increased nutritional risk as well.

Results from this study found that nutrient intakes did not differ between children with an ASD who are food selective (ASD-FS) and children who are not food selective (NFS). Furthermore it was determined that inadequate intakes of fiber, vitamin D, and calcium were common among all of the groups despite food selectivity. According to Zimmer and colleagues (2010), selective eaters were significantly more likely to be at risk of a nutrient deficiency when compared to typically developing children (p<.0001). This study indicates that the findings are not consistent with Zimmer et al., who reported that micronutrient deficiencies in children with an ASD who are food selective are more common and that selective eaters with an ASD consumed significantly less vitamin B12 and vitamin A when compared to typically developing children. Results also illustrated that niacin, magnesium, zinc, calcium were micronutrients that were consumed above the Upper Tolerable Limit (UL). It is not uncommon that these nutrients would be consumed above the UL since they are often found in foods that are fortified (ready to eat cereals, baked goods) and commonly consumed among children (Ford et al. 2012). Magnesium is often used to treat symptoms of constipation in children with an ASD.

While food sources are not considered a risk, the UL recommendation is based on supplemental forms, therefore fortified foods are concerning since they are a synthetic form and often overlooked when analyzing an individual's dietary intake. Similar to magnesium, calcium is used as a complementary and alternative medical approach to treat symptoms of an ASD. In 1996, a small trial found that calcium helps regulate the speed, intensity, and clarity of messages that pass between neurons (Murray, 1996). This study facilitated the recommendation of calcium supplementation in children with an ASD by complementary and alternative medical providers even though it has methodological shortcomings (Levy and Hyman, 2002, 2003, 2005). Zinc is another supplement commonly used as a complementary and alternative medical approach to treat symptoms of an ASD. Zinc is necessary for growth and development, and assists in immune function along with improving taste acuity (Jackson et al., 2000). It has been proposed by McCandless (2009) that zinc will improve sensory processing impairments in children with an ASD (McCandless 2009) but further research is necessary in order to determine the efficacy of supplementation in children with zinc. Consuming food sources at the upper tolerable level (UL) of calcium, magnesium, and zinc is likely to not produce an adverse effect, but above the UL is not advised. Toxicity symptoms of magnesium, zinc, and calcium include gastrointestinal symptoms (i.e., cramping, diarrhea).

The association between food selectivity and total kilocalorie consumption is significantly different between the groups (ASD-FS compared to NFS groups, p=0.04). The ASD-FS group consumed 130 calories more than ASD-NFS participants. This may be due to the type of food selectivity that the children in the ASD group exhibit. For example, the ASD-FS child is most likely consuming more energy dense food items within each food group, such as fried chicken compared to a grilled chicken breast, a bagel compared to a slice of bread, or a ½ cup of avocado compared to a ½ cup of strawberries. It is not understood why children with an ASD are more likely to be food selective. It has been hypothesized that it is due to sensory processing impairments, oral motor dysfunction, core deficits of an ASD (rigidity, inflexibility) and/or environmental factors (parental style, cultural preferences, or feeding environment) (Bennetto et al., 2007; Zimmer et al., 2012).

Contrary to our prediction, children with an ASD who were food selective did not appear to be at an increased risk of becoming overweight and/or obese. Previous literature and the current dataset demonstrated that children with an ASD, who are food selective, preferred energy dense foods which may contribute to the development of overweight and/or obesity over a period of time. Greater detail and more research are needed to better understand the correlation between BMI status and food selectivity in children with an ASD.

Dietary Intake

Conflicting results about nutritional status in children with an ASD have been reported (Herndon et al. 2010; Emond et al., 2010; Levy et al., 2007; Schreck et al. 2004). Some research has stated dietary intakes of children with an ASD do not differ from typically developing children (Emond et al., 2010; Levy et al., 2007). Other investigators have reported that children with an ASD were not meeting Dietary Reference Intakes (DRIs) for various nutrients (Herndon et al.,2009; Wei et al., 2010; Bandini et al., 2010). Nutritional risk can be defined as something that compromises a child’s ability to consume a variety of foods and necessary nutrients for healthy growth and development (Sermet-Gaudelus et al., 2000).

Results from the current study support existing literature that children with an ASD did not appear to be at an increased nutritional risk for the majority of macronutrients and micronutrients.

Dietary intakes were determined for the following outcome variables: total kilocalorie, total protein, total carbohydrate, total fat, fiber, calcium, vitamin D, vitamin B12, magnesium, niacin, and folic acid. Findings support existing data, whereby children with an ASD consumed significantly less folic acid (Wei et al., 2010), significantly less zinc (Cornish,1998), and significantly less protein (Bandini et al., 2010) when compared to the NIC and TD groups; however, all three groups consumed greater than 80% of the dietary reference intakes, indicating minimal nutritional risk.

Examination of food groups showed that dietary patterns of intake differed among the three groups. Children with an ASD were found to consume approximately half a serving less of vegetables, fats, grains, protein, and one serving less of dairy; but within the fats/sweets/oils food group, they consume more energy dense foods when compared to the typically developing group. Results were similar to Evans et al., (2012), who indicated that children with an ASD consumed fewer servings of vegetables, fruits, and more energy dense foods. Further, Schreck et al., (2004) also found that children with an ASD consumed fewer servings from each food group (fruits, vegetables, protein, dairy, fats, and grains). In this study, data are suggesting a trend that children with an ASD are not at an increased nutritional risk between the ages of two to six years even though they consume fewer servings of the food groups.

Although their results are similar to the results presented in the current study, Schreck et al. did not analyze a three day food record, but rather a food preference inventory which is not commonly used in dietary intake research. The food preference inventory was a listing of foods from the five food groups: fruits, vegetables, dairy, proteins and starches, and parents were asked to indicate if their child consumed a particular food in the food group and if they thought it was an appropriate serving. Even though children with an ASD consume fewer servings of food within the food groups, data suggests that they consume approximately the same total kilocalories when comparing them to the NIC and TD groups. In this study, data reveals that children with an ASD are consuming more energy dense foods (ASD: 1.64; NIC: 1.31; TD: 1.31) within the food groups (i.e., chicken nuggets, hot dogs, peanut butter, cakes, pastries, crackers, chips, cookies, or snack bars) even though they are consuming fewer servings compared to the typically developing children (p=.05). The ASD and NIC group consumed more energy dense foods when compared to the TD group, but the ASD and NIC group did not differ. These findings suggest that dietary patterns of intake are similar in the ASD and NIC groups, but further examination on why they consume more energy dense foods is needed. Results from this study support Evans, et al.'s (2012), findings that 53 children with an ASD consumed significantly more energy dense foods (i.e., chicken nuggets, hot dogs, peanut butter, cakes, crackers, chips, cookies, and snack bars) when compared to 58 typically developing children (p=0.01). Another study examining dietary changes in typically developing children, ages two to six years old, between 1998-2008, saw an increase in energy dense foods and total calories consumed (Ford et al., 2013). These researchers analyzed 10,647 24-hour food recalls and saw an increased intake of savory snacks (+51 calories), sweet snacks and candy (+25 calories), mixed Mexican dishes (+22 calories), cheese (+21 calories), and fruit juice (+18 calories) (Ford et al., 2013). Poti and Popkins also examined trends in total kilocalorie intake among typically developing children living in the United States (Poti and Popkins, 2011). They too reported that children's mean energy consumption increased by 160 calories between 1978-1997 and 2003-2006. The results from this study clearly illustrates that dietary intake patterns are concerning among children with an ASD since they consume fewer servings of foods but appear to have minimal differences in total kilocalories.

Fiber intake was below the Adequate Intake recommendation of 19-25 grams in all three groups in our study which is similar to Herndon and colleagues' findings (Herndon et al., 2009). Herndon et al. reported that 94% of the 46 children with an ASD and 100% of the 31 TD children did not meet the Dietary Reference Intakes (DRI) for fiber. Afzal and colleagues found that children with an ASD suffered with constipation more often than typically developing children (ASD: 36%; TD: 10%). A decrease in constipation may improve maladaptive behaviors (i.e., irritability, restlessness) seen in children with an ASD, further research should investigate the effects that fiber may have in improving GI symptoms and maladaptive behaviors in children with an ASD (Afzal et al., 2003).

Weight Status

The National Center for Health Statistics (NCHS) reported that approximately one in five children in the United States is overweight (BMI $\geq$ 85th percentile- $\leq$ 95th percentile; NCHS 2014; Ogden et al., 2014); Barlow et al., 1998). Data from the NHANES 2013-2014 indicates that the prevalence of childhood obesity has tripled over the past two decades and has been estimated to affect approximately 8.4%–20.5% of U.S. children ages two to 19 years, and the prevalence of overweight in children is approximately 34.5% (Ogden et al., 2014). Disparities among race, gender, age, geographic region and socioeconomic status exist (Wen et al., 2012). It appears 29% of White girls are overweight/obese compared to 36% of African American and 37% in Hispanic girls (Ogden et al., 2014). Approximately 40% of Hispanic boys are overweight/obese compared to 34% of African American and 28% of White boys (Ogden et al., 2014). Again, overweight in the current study was defined by the CDC sex-specific BMI growth charts as being BMI greater than or equal to the 85th percentile and less than the 95th percentile, and obesity is defined as a BMI greater than the 95th percentile. Obesity can contribute to cardiovascular problems, hypertension, and an increased risk of type two diabetes, sleep apnea, and orthopedic complications, social and psychological problems (Barlow et al., 1998).

Even though it was hypothesized that children with an ASD would have a higher prevalence of overweight, and obesity, BMI data detected no significant differences in BMI percentiles and BMI z-scores among the ASD, NIC, and TD groups. In this study, children with an ASD are growing at a comparable rate to the NIC and TD children. Calculated BMI mean percentile ranks are between the 52nd–60th, percentiles which is considered normal weight. Data indicates that 73% of children with an ASD and NIC children were between 6th–84th percentile compared to 81% of typically developing children ($p>.05$). Bandini et al. found that children with an ASD had an equal or a slightly higher prevalence of obesity (Bandini et al. 2010). Our results were similar to Bandini and colleagues' findings as overweight and obesity prevalence was similar among the groups (p>.05). The prevalence of overweight in children with an ASD was 10 (11%); NIC: 19 (15%); and TD: 12 (9%). Similar results were found when comparing risk of obesity among the three groups (ASD: 9 (10%); NIC: 9 (17%); TD: 4 (3%). Children with an ASD have been reported to have atypical eating patterns, decreased physical activity, motor impairments, low muscle tone, and sensory processing aversions (Curtin et al. 2010), all of which affect the risk of overweight and obesity in children with an ASD. It was expected that the data would show see an increased risk of obesity in children with an ASD when compared to typically developing children. This study hypothesized that all three groups of participants would have equal rates of growth faltering. Growth faltering/underweight was determined by having a BMI less than or equal to the 5th percentile. Growth faltering/underweight (BMI $\leq$ 5th percentile) can have detrimental effects on a child's cardiovascular, social and emotional, reproductive, growth and development health (Food and Agriculture Organization (FAO) 2009). Data in this study also indicated that children with an ASD had similar prevalence of BMI scores less than the 5th percentile in the : ASD: 5(6%); NIC: 6(5%); TD: 9(7%) groups.

Limitations

There are several limitations in this study that should be considered. First, this sample consisted of young children (ages two to six years old) and there were no follow-up measures or initial biochemical indices of nutritional status to compare, which makes it difficult to generalize the findings. As such, the data may not reflect an accurate risk of becoming overweight or obese. Second, there was no follow-up for dietary intake, and the food record only captured those three days; therefore, it may not have adequately captured food selectivity. However, Falciglia and colleagues conducted a study comparing the three day food record to a fifteen-day food record and found that the three-day food record was accurate for predicting nutrient intake and variety (Falciglia et al., 2009). Third, the manner in which the original three day food record data were coded may be considered a limitation. Decisions on how to code certain foods may have impacted the food selectivity results, especially the food variety/repertoire score. Coding decisions were based on the pediatric research assistant's judgment, and coding of a food item sometimes required recoding of several different foods into one group. For example, all alternative milk products were considered to be a single food even though nutrient content is different in almond milk, hemp milk, rice milk, soy milk, etc. Fourth, the operational definition of food selectivity has inherent limitations. The researchers were not able to include food refusal as the third criteria for determining food selectivity since parents were not specifically asked about foods that their child would refuse. Furthermore, it was not possible to gather information regarding whether problematic eating behaviors were addressed in the participants. This could have impacted the food selectivity results and caused an under-reporting of food selectivity. Fifth, a limitation in the current literature is that dietary intake is not measured the same across studies. Studies have collected dietary intake using food frequency questionnaires (Bandini et al. 2010); food preference inventory lists (Schreck and Williams 2004); 24-hour recall (Cornish 1998); and three day food record (Herndon et al. 2009; Levy 2007; Raiten and Massaro 1986). Finally, we analyzed specialty foods (i.e., gluten free bread) as a food item and did not conduct sub-group analyses for children consuming a specialty diet (i.e., gluten and casein free diet).

Strengths

Even though there were limitations in this study, it had many strengths. First, anthropometric measurements were done by study personnel in order to obtain correct weight and height measurements and to eliminate under- or over-reporting by parents. A second strength was that a three day food record was used to assess dietary intake as it is a valid dietary assessment instrument and commonly used in nutritional studies. Third, parents received extensive training on the appropriate method for recording their child's dietary intake in order to obtain the most accurate results. In addition, the sample size was large enough to detect differences among the three groups. Therefore these results can provide a more accurate estimation of the prevalence of overweight and obesity among children with an ASD compared to NIC and TD children. Finally, this study identified food selectivity using an operational and valid definition which allowed selective eaters to be accurately identified.

Chapter 6

Recommendations

Our study is the first to examine food selectivity and weight status in three comparison groups (ASD, NIC, TD). Findings are consistent with previous research in regards to dietary intake and weight status in children with an ASD. The results illustrated that children with an ASD are more likely to be food selective and consume more energy dense foods ($p<.05$). The results should reassure parents that children between ages two to six years of age with an ASD do not appear to be at an increased nutritional risk for under-consumption of the majority of macro- and micronutrients. We did find differences among the three groups in folic acid, zinc, and protein; however, all three groups consumed greater than 80% of estimated requirements; therefore, minimal risk is indicated. Again, parents should feel confident that their child's estimated needs are most likely being met through dietary intake even if their child is food selective.

These findings should provide insight to professionals when they work with children with an ASD who are food selective. Professionals should be aware that food selectivity is more common in children with an ASD. The data clearly illustrate that children with an ASD who are food selective are more likely to consume energy dense foods which can have implications on weight and nutritional status long-term.

Future Directions

Further research is needed to look at factors that may contribute to food selectivity such as sensory processing impairments, oral motor difficulties, maladaptive behaviors, mealtime environment, and parental influence. Greater insight on why children with an ASD suffer with food selectivity is needed in order to design assessment instruments and to develop appropriate nutritional interventions.

Additional research should include adolescent children with an ASD who are food selective in order to determine if their selectivity impacts their nutritional risk and BMI status long term. In addition, using a three day food record at multiple times with a large sample and obtaining biochemical indices would provide relevant information for selective eaters with an ASD.

Future work should investigate children with an ASD who are food selective compared to children who are not food selective, and how dietary intake impacts nutritional status long-term, and what the differences are in total kilocalorie intake.

Many children with an ASD suffer with constipation and based on our findings their fiber intake is extremely low, therefore; future research should investigate the effects that fiber may have in improving GI symptoms and maladaptive behaviors in children with an ASD.

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Appendix A

Table 4. Demographic characteristics of the study participants (n= 403)

	N	%
Child Sex		
Total Male	281	70
Total Female	122	30
Final Groups		
Autism Spectrum Disorder (ASD)	113	28
Neuroimpaired Comparison (NIC)	143	35
Typically Developing (TD)	147	37
Age of Child		
0-2 y	55	14
3 y	51	13
4 y	153	38
5 y	144	35
Missing	9	
Maternal Race/Ethnicity		
Non-Hispanic (White)	276	68
Other Race	64	16
Missing	63	16
Maternal Education		
Advanced Degree	74	19
Bachelors Degree	136	36
High School	75	20
Some College/Trade	97	25
Missing	21	
Income		
Category 1 (<$10,000)	22	.05
Category 2 ($10,000-$30,000	57	14
Category 3 ($30,000-$50,000)	61	15
Category 4 ($50,000-$70,000)	73	18
Category 5 ($70,000-$90,000)	66	16
Category 6 ($90,000-$110,000)	42	10
Category 7 (>$110,000	58	14
Category 0 (missing)	24	.06

Table 5. Number and percent for the eight categories of maternal income, five categories for maternal education, three categories for maternal race/ethnicity among the ASD, NIC, and TD participants

	Total		ASD		NIC		TD	
	n=403		n=113		n=143		n=147	
	n	%	n	%	n	%	n	%
Income								
Category 1 (<$10,000)	22	5	8	7	10	7	4	3
Category 2 ($10,000-$30,000)	57	14	20	18	25	17	12	8
Category 3 ($30,000-$50,000)	61	15	22	20	21	14	18	12
Category 4 ($50,000-$70,000)	73	18	21	19	18	13	34	23
Category 5 ($70,000-$90,000)	66	16	16	14	24	17	26	18
Category 6 ($90,000-$110,000)	42	10	10	9	12	8	20	14
Category 7 (>$110,000)	58	14	14	12	18	13	26	18
Category 0 (missing)	24	6	2	1	15	11	7	4
Education								
Advanced Degree	74	18	17	15	24	17	33	22
Bachelors Degree	136	34	34	30	42	29	60	41
High School	75	19	19	17	33	23	23	16
Some College/Trade	97	24	40	36	29	20	28	19
Missing	21	5	3	2	15	11	3	2
Race/Ethnicity								
Non-Hispanic (White)	276	69	82	73	82	57	112	76
Other-Race	64	16	23	20	21	15	20	14
Missing	63	15	8	7	40	28	15	10

Table 6.Total number and percent of child sex and age of child among the ASD, NIC, and TD participants

	Total 403		ASD 113		NIC 143		TD 147	
	n	%	n	%	n	%	n	%
Child Sex								
Male	281	70	100	89	100	70	81	55
female	122	30	13	11	43	30	66	45
Age								
0-2 years	55	14	22	20	15	10	18	12
3 years	51	13	6	5	17	12	28	19
4 years	153	38	43	38	55	39	55	37
5 years	144	36	42	37	56	39	46	3
Missing	9							

Table 7. Means and standard deviations of total kilocalories, carbohydrate (CHO), protein, fat, and fiber distributions among the ASD, NIC, and TD groups

	Total Kilocalories		Total CHO (g)		Total Protein(g)		Total Fat(g)		Total Fiber(g)	
	M	SD	M	SD	M	SD	M	SD	M	SD
ASD (n=113)	1399.2	393.6	203.2	57.0	48.4[a]	14.3	51.9	20.3	11.6	5.1
NIC (n=143)	1394.8	368.5	198.1	55.6	52.3[b]	15.4	52.6	17.5	11.5	5.0
TD (n=147)	1404.0	292.3	196.9	47.5	53.2[b]	13.1	52.5	13.7	11.6	3.9

Test: ANCOVA. Means are corrected for child sex, age of child, maternal race, maternal education, maternal income, and total kilocalories consumed. Means with different superscripts are significantly different at p value <.05

[a] =p value 0.005 (ASD compared to NIC)

[b]= p value 0.001 (ASD compared to TD)

Table 8. One-Way Analysis of Variance Summary Table comparing total fat, calories, protein, and carbohydrate distributions among the ASD, NIC, and TD groups

	df	F	p
Total Fat (g)			
Group	2	.18	.84
Child Sex	1	.47	.49
Maternal Education	4	.20	.94
Maternal Race	2	.49	.61
Income	7	.64	.72
Age	3	.40	.76
Total Kcal	1	925.97	**.00**
Total kilocalories (kcals)			
Group	2	.02	.98
Child Sex	1	4.5	**.03**
Maternal Education	4	.30	.88
Maternal Race	2	.53	.59
Income	7	.39	.91
Age	3	2.0	.11
Total Protein			
Group	2	6.26	**.002**
Child Sex	1	1.81	.179
Maternal Education	4	1.25	.290
Maternal Race	2	4.53	**.011**
Income	7	1.02	.420
Age	3	0.45	.720
Total Kcal	1	349.4	**.001**
Total Carbohydrates			
Group	2	1.76	.173
Child Sex	1	0.97	.325
Maternal Education	4	0.23	.920
Maternal Race	2	1.06	.347
Income	7	0.73	.644
Age	3	0.34	.798
Total Kcal	1	1276.84	**.001**

Main effect for gender, maternal education, maternal race, income, age, and total kilocalorie is presented in chart. Significance set at p value $\leq .05$. Bold indicates $p<.05$

Table 9. Means and standard deviations for calcium, vitamin D, iron, zinc, and vitamin B12 intake distributions among the ASD, NIC, and TD groups

	Calcium(mg)		Vitamin D(mcg)		Iron(mg)		Zinc		Vitamin B12	
	M	SD	M	SD	M	SD	M	SD	M	SD
ASD	836.2	359.8	6.2	4.5	10.5	4.1	7.0^{a}	2.7	4.0	2.0
NIC	872.6	296.6	5.9	2.8	11.0	3.9	7.8^{b}	2.7	4.3	1.8
TD	855.7	318.9	6.4	5.0	11.1	3.9	7.6^{b}	2.7	4.1	1.7

Test: ANCOVA. Means are corrected for child sex, age of child, maternal race, maternal education, maternal income, and total kilocalories consumed. Means with different superscripts are significantly different at the p <.05 level

^{a}= p value 0.009 (ASD compared to NIC)

^{b}= p value 0.05 (ASD compared to TD)

Table 10. Means and standard deviations for magnesium, folic acid, niacin intake distributions among the ASD, NIC, and TD groups

	Magnesium(mg)		Folic Acid(mcg)		Niacin(mg)	
	M	SD	M	SD	M	SD
ASD (n=113)	199.3	76.3	369.9^{a}	182.4	15.2	5.3
NIC (n=143)	188.8	62.4	$405.8^{a,b}$	177.8	14.7	4.8
TD (n= 147)	185.9	48.5	429.9^{b}	197.1	15.5	4.8

Test: ANCOVA. Data not normally distributed, log transformations were conducted. Numbers in table are presented in original data units. Significance set at the p value <.05. Means are corrected for child sex, age of child, maternal race, maternal education, maternal income, and total kilocalories consumed. Means with different superscripts are significantly different at p <.05; a= p value 0.007 (ASD compared to TD)

Table 11. Body Mass Index (BMI) percentile and Z scores (mean and standard deviation) among the ASD, NIC, and TD participants (n=347)

	n	Mean	SD(+/-)
BMI Percentile			
ASD	90	59.5	29.78
NIC	128	53.04	30.05
TD	129	52.11	28.65
BMI Z-score			
ASD	90	.238	1.15
NIC	128	.081	1.05
TD	129	-.029	1.04

Table 12. BMI distribution by percentile among the ASD, NIC, and TD groups (n=347)

	Percentiles							
	≤ 5th		6th-84th		85th-95th		> 95th	
	n	%	n	%	n	%	n	%
ASD (n=90)	5	6	66	73	10	11	9	10
NIC (n=128)	6	5	94	73	19	15	9	7
TD (n= 129)	9	7	104	81	12	9	4	3
TOTAL	20		264		41		22	

Table 13. Number and percent of total foods eaten, high frequency single food intake (HFSFI), food selectivity among the three groups (ASD, NIC and TD)

	Total 403		ASD 113		NIC 143		TD 147	
Total foods eaten	n	%	n	%	n	%	n	%
< 22	75	19	34	30	23	16	18	12
> 23	328	81	79	70	120	84	129	88
High frequency single food intake (HFSFI)*								
yes	94	23	38	34	29	20	27	18
no	309	77	75	67	114	80	120	81
Total food selectivity								
yes	135	33	52	46	45	31	38	26
no	267	66	60	54	98	69	109	74

*HFSFI is defined as a food item eaten > four times in a day

Limited food repertoire is defined as consuming < 22 different food items per day

Table 14. Means and standard deviations for the number of foods consumed among the ASD, NIC, and TD groups

		Number of foods consumed	
Group	n	M	SD
ASD	113	24.5^{a}	6.75
NIC	143	27.4^{b}	5.86
TD	147	29.0^{c}	5.65

Test: ANCOVA. Means are corrected for child sex, age of child, maternal race, maternal education, maternal income, and total kilocalories consumed. Means with different superscripts are significantly different at p value <.05

^{a,b} = p value .0.00 (ASD compared to NIC and TD)

^{c}= p value 0.03 (NIC compared to TD)

Table 15. Mean and standard deviations for high frequency single food intake (HFSFI) among the ASD, NIC, and TD groups

	HFSFI	
Group	M	SD
ASD (n= 112)	.374[a]	.47
NIC (n= 143)	.232[b]	.40
TD (n=147)	.205[b]	.39

Test: ANCOVA. Data is not normally distributed, logit transformations were conducted. HFSFI is a binary response (yes or no). Means are corrected for child's sex, age, maternal income, maternal education, and total kilocalories consumed. Means with different superscripts are significantly different at a p value <.05

[a]= p value .0.04 (ASD compared to NIC)

[b]= p value 0.02 (ASD compared to TD)

Table 16. Mean and standard deviations for food selectivity among the ASD, NIC, and TD groups

	Food Selectivity	
Group	M	SD
ASD (n= 112)	.48[a]	.50
NIC (n= 143)	.33[b]	.47
TD (n=147)	.26[b]	.44

Test: ANCOVA. Data is not normally distributed; numbers in table are logit transformed. HFSFI is a binary response (yes or no). Means are corrected for child's sex, age, maternal income, maternal education, and total kilocalories consumed. Means with different superscripts are significantly different at a p value <.05

[a]= p value .0.04 (ASD compared to NIC)

[b]= p value 0.00 (ASD compared to TD)

Table 17. One-Way Analysis of Variance Summary comparing total number of foods consumed, high frequency single food intake (HFSFI) and food selectivity (FS)

	df	F	p
Limited food repertoire			
Group (ASD, NIC, TD)	2	15.73	**<0.0001**
High frequency single food intake	2	3.85	**0.02**
Group (ASD, NIC, TD)			
Food Selectivity	2	4.87	**0.008**
Group (ASD, NIC, TD)			

Main effect for final group (ASD, NIC, TD) and covariates

Table 18. Number and percent of children with an ASD who are food selective (FS) compared to children who are not food selective (NS) not meeting Estimated Average Requirements (EAR).

		Non-Selective		
	ASD-FS(%)	ASD-NFS (%)	NIC-NFS (%)	TD-NFS (%)
	n=52	n=60	n=98	n=109
	n (%)	n (%)	n (%)	n (%)
Total Carbohydrate	0	1	1	0
Protein	0	0	0	0
Total Fat	0	0	0	0
Total Energy	0	0	0	0
Total Fiber	37(71)	46(77)	78(80)	73(67)
Vitamin D	22(42)	23(38)	38(39)	38(35)
Niacin	1	0	0	0
Folate	0	0	0	0
Vit B12	0	2	0	0
Iron	0	0	0	0
Magnesium	2	3	2	2
Zinc	2	1	0	0
Calcium	20(38)	26(43)	35(36)	30(28)

There were no significant difference among the groups (vitamin D: p=0.80; calcium: p=0.19; fiber: p=0.95)

Table 19. Number and percent of children with an ASD who are food selective (FS) compared to children who are not food selective (NS) at or above the Upper tolerable limit (UL).

		Non Food Selective (NS)		
	ASD-FS (52)	ASD-NS (60)	NIC-NS (98)	TD-NS (109)
Niacin	23 (44)	19 (32)	34 (35)	32 (29)
Magnesium	36 (69)	43 (71)	76 (78)	71 (65)
Zinc	4 (8)	2 (3)	7 (7)	7 (6)
Calcium	38 (73)	46 (77)	78 (80)	73 (67)

n=319. There were no significant differences among the groups (p>.05)

Table 20. Comparison of daily dietary patterns among the ASD, NIC, and TD groups (M, SD)

Dietary Pattern	ASD	NIC	TD
Fruit	1.27 (.61)	1.22 (.60)	1.30 (.65)
Vegetable	2.50 (1.61)	2.92 (1.40)	3.00 (1.46)
Fats/sweets/oils	8.20 (2.56)	8.13 (2.75)	8.60 (2.48)
Energy dense snacks	1.65 (0.11)	1.41 (0.92)	1.37 (0.93)
Grains	3.66 (1.60)	4.00 (1.64)	4.25 (1.58)
Dairy	3.47 (1.71)	3.94 (1.51)	4.40 (1.49)
Protein	3.88 (1.82)	4.29 (1.50)	4.55 (1.59)

ASD was significantly different in vegetable compared to NIC p=0.008 and to TD p=.002

ASD is significantly different in fats/sweets/oils compared to TD p=0.03

ASD is significantly different in energy dense snacks compared to TD p=0.05

ASD is significantly different in grains compared to NIC p=.05 and to TD p=0.002

ASD is significantly different in dairy compared to NIC p=.003 and TD=<.0001

ASD is significantly different in protein compared to NIC p=.05 and TD p=0.00

Table 21. Total mean and standard deviations for calorie intake among children with an ASD and who are food selective compared to children who are not food selective.

	N	M	SD
Total calorie intake			
ASD-food selective	52	1457^{a}	461
ASD-non-food selective	60	1327^{b}	313
NIC-non- food selective	98	1383^{b}	341
TD-non-food selective	109	1400^{b}	273

Test: ANCOVA. Means are corrected for child sex, age of child, maternal race, maternal education, maternal income, and total kilocalories consumed. Means with different superscripts are significantly different at the p value <.05

[a] = p value 0.04 (ASD-food selective compared to ASD-non-food selective, NIC- non-food selective, TD-non-food selective)

Table22. At risk of overweight (BMI 85th-95th percentile) and obese (> 99th percentile) among children with an ASD who are food selective (ASD-FS) compared to children who are not food selective (ASD-NFS, NIC-NFS, TD-NFS).

	N	%
At Risk Overweight (BMI 85-95th percentile)		
ASD-FS	6/41	15
ASD-NFS	4/49	8
NIC-NFS	13/89	15
TD-NFS	10/95	11
Obese		
ASD-FS	1/41	2
ASD-NFS	8/49	16
NIC-NFS	7/89	8
TD-NFS	2/95	2

There are no significant differences among the groups (p value > .05)

Table23. Mean and standard deviation BMI Z-Scores among ASD who are food selective compared to the participants who are not food selective.

	n	M	SD
ASD- Food Selective (FS)	41	.065	1.15
Non-Food Selective (NFS)	234	.099	1.05

Means are corrected for child sex, age of child, maternal race, maternal education, maternal income, and total kilocalories consumed. There are no significant differences between the two groups (p value >.05)

Table24. Mean and standard deviation BMI percentiles among children with an ASD who are food selective (ASD-FS) compared to participants who are not food selective

	n	M	SD
ASD-Food Selective (FS)	41	55	28.65
Non-Food Selective (NFS)	234	54	29.70

Means are corrected for child sex, age of child, maternal race, maternal education, maternal income, and total kilocalories consumed. There are no significant differences between the two groups (p value=0.74)

Table25. One-Way Analysis of Variance Summary comparing calcium, vitamin D, zinc, B12, magnesium, folic acid, niacin, and iron

	df	F	p
Total Calcium			
Group (ASD, NIC, TD)	2	0.47	0.63
Total vitamin D	2	0.65	0.52
Group (ASD, NIC, TD)			
Total zinc	2	3.59	**0.03**
Group (ASD, NIC, TD)			
Total vitamin B12	2	1.54	0.22
Group (ASD, NIC, TD)			
Magnesium	2	1.02	0.36
Group (ASD, NIC, TD)			
Folic Acid	2	3.80	**0.02**
Group (ASD, NIC, TD)			
Niacin	2	1.35	0.26
Group (ASD, NIC, TD)			
Iron	2	1.38	0.25
Group (ASD, NIC, TD)			

Main effect for final group (ASD, NIC, TD)

Table 26. Consumed foods in each group

Food Group	Included foods
Fruit:	fresh and frozen fruit, dried fruit, canned fruit, apples, apricots, bananas, cherries, grapefruit, grapes, kiwi fruit, lemons, limes, mangoes, nectarines, oranges, peaches, pears, papaya, pineapple, plums, prunes, raisins, tangerines, strawberries, blueberries, raspberries, cantaloupe, honeydew, watermelon, fruit cocktail, avocado
Vegetable:	bok choy, broccoli, collard greens, dark green leafy vegetables, kale, mustard greens, romaine lettuce, spinach, turnip greens, watercress, corn, field peas, potatoes, acorn squash, butternut squash, pumpkin, peppers (all colors), carrots, sweet potatoes, tomatoes, tomato juice, , artichokes, asparagus, bean sprouts, cabbage, cauliflower, celery, cucumbers, eggplant, green beans, iceberg lettuce, mushrooms, Okra, onions, Turnips, zucchini
Fats, sweets, oils:	Cake, cookies, pies, pastries, donuts, chocolate candy, frosting, sugar glazes, oil, margarines, butter, shortening, reduced fat margarine, sweetened soda, artificial sweetened fruit drink, artificial sweetened soda, french fries, potato chips, all types of snack chips, snack bars, frozen milk shakes, maple syrup, honey, jams, jelly, reduced fat condiments, ketchup, mustard, relish, fat free condiments, full fat salad dressings, reduced fat salad dressing, fat free salad dressing
Grains:	all types of breads, all bagels, rice, couscous, pasta, amaranth, brown rice, buckwheat, bulgur, millet, oatmeal, popcorn, rolled oats, quinoa, sorghum, triticale, barley, rye, cornmeal, whole wheat bread, crackers, tortillas, muesli, couscous, grits, pretzels, pitas, cornbread
Dairy:	cow's milk, goats milk, yogurt, cheese, pudding, ice milk, frozen yogurt, ice cream
Protein:	meat, poultry, seafood, beans and peas, eggs, processed soy products, nuts, and seeds are considered part of the Protein Foods Group. Lean cuts of: beef, ham, lamb, pork, veal, bison, rabbit, venison, chicken, goose, turkey, bean burgers, black beans, black-eyed peas, chickpeas, falafel, kidney beans, lima beans, navy beans, pinto beans, soy beans, split peas, white beans, tempeh, texturized vegetable protein, tofu, almonds, cashews, hazelnuts, mixed nuts, peanuts, peanut butter, pecans, pistachios, pumpkin seeds, sesame seeds, sunflower seeds, walnuts

Appendix B

STUDY TO EXPLORE EARLY DEVELOPMENT

Study to Explore Early Development

Information about the Diet and Stool Diary

Thank you for your interest in the Study to Explore Early Development (SEED). This packet contains a diary for you to complete. More instructions about how to complete the diary are on the next pages. **Someone from the study will call you in the next few days** to make sure you have started the diary, help you complete materials if needed, and answer your questions.

When you have completed the diary, please send it back in the postage-paid envelope provided. If you have any questions while you are completing these forms (or want help before you begin), please call and we'll be happy to help you.

We are grateful to you for your willingness to participate in this important research study. If you would like to speak to anyone at any point during the study, please call the number below.

If you have questions, call

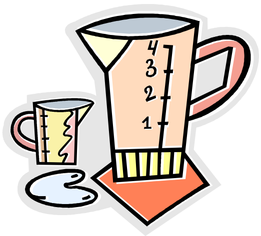
Andrea Cantarero
Research Assistant
303.724.7655

Important Food Diary Do's and Don'ts

- Stick to normal eating habits.

- For EVERYTHING that your child eats or drinks, *including* *vitamins*, *herbs* and other *supplements*, record:

1. The time the item was consumed
2. The serving size or amount eaten
3. What your child ate
4. The brand name
5. Any special details about the type of food
6. A detailed description of how the food was prepared



Helpful Hint #1:

Take the diary with you everywhere you go, so you won't forget what your child eats or drinks.

Helpful Hint #2:

Vitamins and Supplements

Time	Amount	What did you eat?	Brand name	Type	Pre
8 :15 am	250mg	Vitamin C	Puritan's Pride	with rose hips	
	1 pill	multi-vitamin	Flintstones	Gummies	

- Use one line on the food diary page for *each* item: This means that **Home Cooked Foods** or **Sandwiches** could take several lines to describe, but that's OK. For things like homemade **Casserole**, put the **proportion** that your child ate (on the first line) followed by the ENTIRE recipe (listed by ingredient) underneath. For instance:

One serving of a homemade cheesy-beef casserole

T	Amount	What did you eat?	Brand Name	Type	Preparation
5	1/12	cheesy-beef casserole	N/A	homemade	ingredients below
	1 lb	beef	Harris Teeter Reserve	ground chuck, 15% lean	pan-fried and drained
	¼ cup	onion		yellow	finely chopped
	7.5 oz box	macaroni and cheese	Kraft	Original	cooked
	¼ cup	milk	King Sooper's	2%	with macaroni
	2 TBSP	butter	Land O Lakes	Whipped	with macaroni

A turkey sandwich

Time	Amount	What did you eat?	Brand Name	Type	Preparation
12:00	3/4	turkey sandwich		homemade	
	2 slices	bread	Wonder	Whole Grain White	toasted
	3 oz	turkey	Sara Lee	Oven Roasted	
	1/8	tomato	Harris Teeter	tennis ball sized	sliced
	1 slice	cheese	Kraft - Select	American Singles	
	1 tsp	mayonnaise	Hellman's	Light	

Note: Instead of recording "2 slices" of turkey, record the amount you use by weight.

You can calculate the weight of each slice by using the package weight divided by the number of slices in the package. Example:1 packet of turkey contains 28 slices and weighs 14 ounces, so…

- Record exactly what you added to prepared mixes like pancakes and macaroni and cheese. For example, instead of recording just Bisquick pancakes, also record that 2 large eggs and 1 cup of 2% milk were added to the mix.

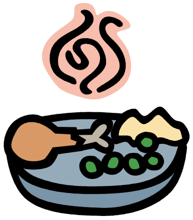
An ice cream sundae

Time	Amount	What did you eat?	Brand Name	Type	Preparation
3:00 pm	1/2	Sundae		homemade	ingredients below
	¼ cup	vanilla ice cream	Dreyer's	Yogurt Blends	
	¼ cup	strawberry ice cream	Dreyer's	No Added Sugar	
	1 TBSP	chocolate syrup	Hershey's	with Calcium	
	2 TBSP	peanuts	Planters	Dry Roasted	

- For **Dry Ingredients** use *CUPS*.
For **Liquids** use *OUNCES*.

Time	Amount	What did you eat?	Brand name	Type	Preparation
7:45 am	¾ cup	Cheerios	General Mills	regular	with milk
	5 oz	Milk	Colorado Proud	2%	

- For **Condiments**, such as *sour cream* or *ketchup*, please use specific amounts to measure by.



Both of these are *good*:

Time	Amount	What did you eat?	Brand name	Type	Preparatio
6:30 pm	golf ball size	sour cream	Daisy	regular	
6:35 pm	2 TBSP	ketchup	Heinz	regular	

These two are bad:

Time	Amount	What did you eat?	Brand name	Type	Preparatio
6:30 pm	a dollop	sour cream	Daisy	regular	
6:35 pm	6 packets	ketchup	Heinz	regular	

- Be very detailed when recording your child’s intake, even for **Fast Food**.

Like this:

Time	Amount	What did you eat?	Brand name	Type	Preparation
2:15 pm	4	Chicken Nuggets	McDonald’s		
	1 kid-size order	French Fries	McDonald’s		
	12 oz	soda	Coca-Cola	diet	

Not like this:

Time	Amount	What did you eat?	Brand name	Type	Preparation
2:15 pm	all	Chicken Nuggets Happy Meal	McDonald’s		

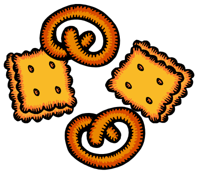
- Avoid using “slices” for anything other than bread, cheese, or bacon. For example, when eating **Pizza**, please record what portion of the total pizza was eaten and the size of the pizza.

Do this:

Time	Amount	What did you eat?	Brand name	Type	Preparation
7:00 pm	1/ 8	14 inch Large Extra Cheese Pizza	Domino’s	Hand-tossed Crust	

Don’t do this:

Time	Amount	What did you eat?	Brand name	Type	Preparation
7:00 pm	1 slice	Large Extra Cheese Pizza	Domino’s		



- When it comes to **Snacks**, like *crackers*, use a measured amount or a specific number:

This works:

Time	Amount	What did you eat?	Brand name	Type	Preparation
9:25 am	½ cup	Cheez-Its	Sunshine	Cheddar	

This works too:

Time	Amount	What did you eat?	Brand name	Type	Preparation
9:25 am	22	Cheez-Its	Sunshine	Cheddar	

This doesn't work:

Time	Amount	What did you eat?	Brand name	Type	Preparation
9:25 am	Small handful	Cheez-its	Sunshine	Cheddar	

- And for **Drinks**…use the actual amount in oz. or ml.
- For water, write if it is bottled or from the tap.

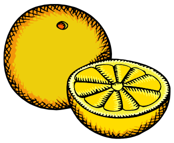
Fantastic:

Time	Amount	What did you eat?	Brand name	Type	Preparation
11 am	12 oz	soda	Pepsi	cola	
1 pm	6.75 oz	juice	Capri Sun	Strawberry Kiwi	
3 pm	12 oz	water	Aquafina	pure water	

Not so fantastic:

Time	Amount	What did you eat?	Brand name	Type	Preparation
11 am	1 can	soda	Pepsi	cola	
1 pm	1 pouch	juice	Capri Sun	Strawberry Kiwi	
3 pm	I bottle	water			

- For whole pieces of **Fruit**, estimate their size by using similar objects:



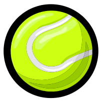
Time	Amount	What did you eat?	Brand name	Type	Preparation
8:45 am	½	tennis ball sized apple		Fuji	Chunked
10:30 am	1	golf ball sized plum		red	
2:15 pm	1	softball sized grapefruit		pink	
3:45pm	½	8 inch banana	Chiquita		sliced

Portion sizes are important, so make sure you write one for every item. Please refer to the “Visualize Your Portion Size” sheet and record everything in terms that you are comfortable with. Thank You!

Visualize Your Portion Size

Visual hints-

- ¼ cup is about the size of a golf ball or ping pong ball.
- 1 cup is about the size of a baseball or tennis ball.
- A 1 inch diameter sauce cup will hold one ounce.
- A ‘pint’ deli container holds 16 oz or about 2 cups.

1 cup =

Tennis ball

¼ cup =

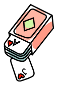
Golf ball

Meats and Fish-

- 3 oz serving is similar in size to a deck of cards, an audiotape, or a checkbook.
- 1 oz of cooked meat is similar in size to 3 dice.
- A 1-inch meatball is about one ounce.
- 4 oz of raw, lean meat shrinks to about 3 ounces after cooking.

3 oz =

Checkbook


3 oz = Deck of cards

Fruits and Veggies-

- A medium apple, peach, or orange is about the size of a tennis ball.
- A small piece of fruit is the size of a golf ball.
- A large piece of fruit is the size of a baseball; a really large piece is about the size of a softball.
- For cut fruit and vegetables such as watermelon, broccoli, or peas, use cups

Cereal and Pasta-

- 1-cup pasta is about the size of a tennis ball.
- An average bagel is the size of a hockey puck.

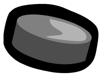
Cheese, Butter and Spreads-

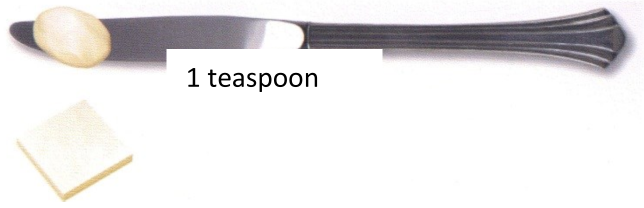
- 1 oz of cheese is about a 1 inch square or about the size of your thumb or four stacked dice.
- 1 Tbsp of peanut butter / butter is about the size of your thumb.
- 1 tsp of peanut butter is the size of the area from the base of your thumbnail to the tip of your thumb.
- A typical salad dressing ladle in a restaurant will hold 3-4 Tbsp of dressing.

1 oz cooked meat = 3 dice



1 tablespoon

1 bagel =

Hockey puck

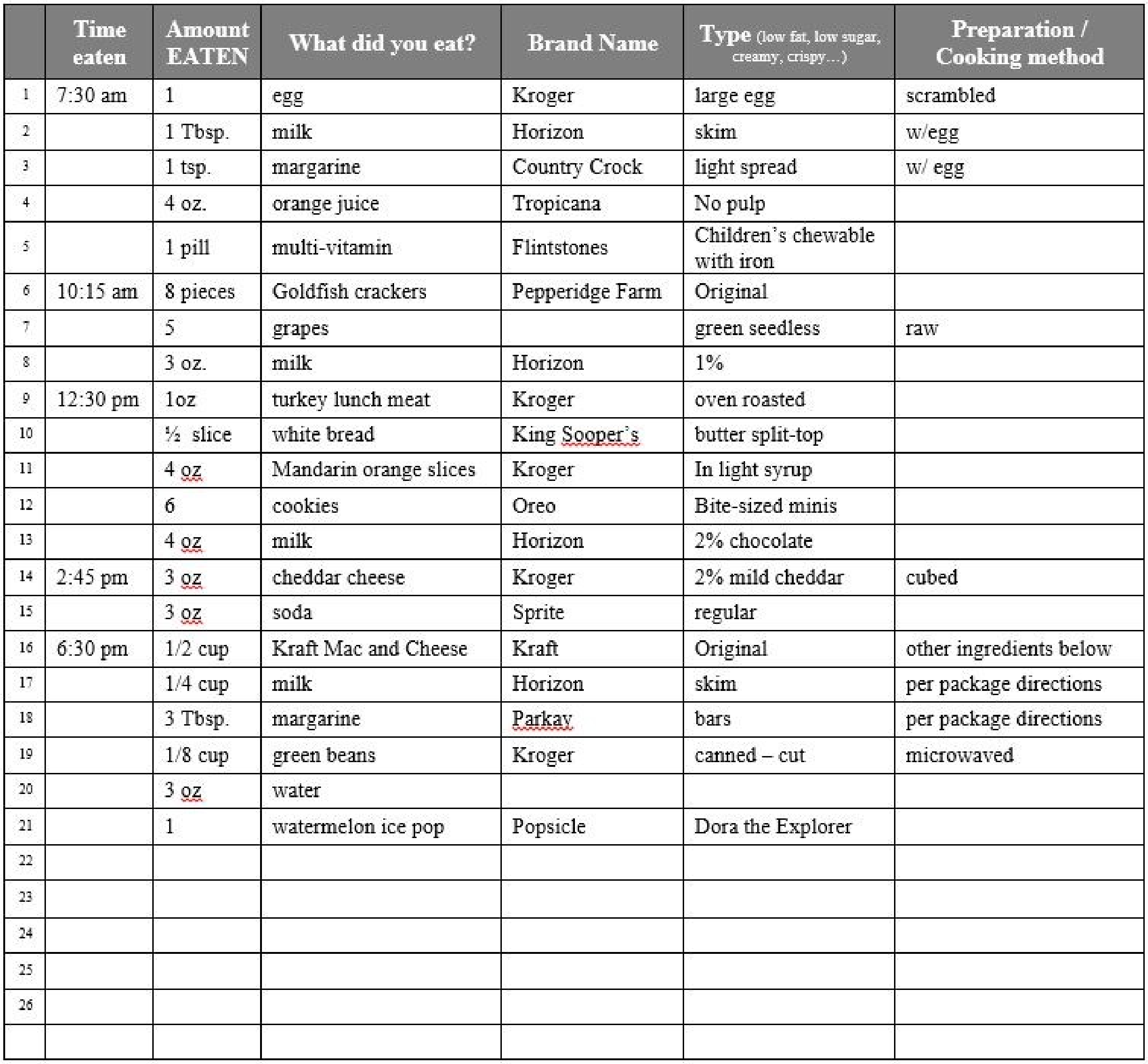

1 teaspoon

Example of Complete Toddler Food Diary

Today's DATE: 12/3/2008

Day of week: M Tu W [✓ Th] F Sa Su

Please circle the day of the week



	Time eaten	Amount EATEN	What did you eat?	Brand Name	Type (low fat, low sugar, creamy, crispy…)	Preparation / Cooking method
1	7:30 am	1	egg	Kroger	large egg	scrambled
2		1 Tbsp.	milk	Horizon	skim	w/egg
3		1 tsp.	margarine	Country Crock	light spread	w/ egg
4		4 oz.	orange juice	Tropicana	No pulp	
5		1 pill	multi-vitamin	Flintstones	Children's chewable with iron	
6	10:15 am	8 pieces	Goldfish crackers	Pepperidge Farm	Original	
7		5	grapes		green seedless	raw
8		3 oz.	milk	Horizon	1%	
9	12:30 pm	1oz	turkey lunch meat	Kroger	oven roasted	
10		½ slice	white bread	King Sooper's	butter split-top	
11		4 oz	Mandarin orange slices	Kroger	In light syrup	
12		6	cookies	Oreo	Bite-sized minis	
13		4 oz	milk	Horizon	2% chocolate	
14	2:45 pm	3 oz	cheddar cheese	Kroger	2% mild cheddar	cubed
15		3 oz	soda	Sprite	regular	
16	6:30 pm	1/2 cup	Kraft Mac and Cheese	Kraft	Original	other ingredients below
17		1/4 cup	milk	Horizon	skim	per package directions
18		3 Tbsp.	margarine	Parkay	bars	per package directions
19		1/8 cup	green beans	Kroger	canned – cut	microwaved
20		3 oz	water			
21		1	watermelon ice pop	Popsicle	Dora the Explorer	
22						
23						
24						
25						
26						

Example of Incomplete Toddler Food Diary

Today’s DATE:___12/3/2008___

Day of week: M Tu W [✓ Th] F Sa Su

Please circle the day of the week

	Time eaten	Amount EATEN	What did you eat?	Brand Name	Type (low fat, low sugar, creamy, crispy…)	Preparation / Cooking method
1	7:30 am	1	scrambled egg			scrambled
2		1 glass	orange juice	Tropicana		
3		1	vitamin	Flintstones		
4	10:00 am	1 handful	Goldfish crackers	Goldfish	cheese	
5		1 small handful	grapes			raw
6		½ glass	milk	Horizon	low fat	
7	12:00 pm	1 slice	turkey	Kroger	lunchmeat	cooked
8		½ slice	bread		White	
9		1	mandarin orange slices	Kroger	snack cups	
10		1 bag	cookies	Oreos	minis	
11		1 glass	milk	Horizon	2% chocolate	
12	2:30 pm	3 cubes	cheese	Kroger	cheddar	
13		1	Sprite			
14	6:30 pm	½ c.	macaroni and cheese	Kraft		cooked
15		3	green beans	Kroger		cooked
16		1 glass	water			
17		1	popsicle		watermelon	
18						
19						
20						
21						
22						
23						
24						

Appendix C

SEED Physical Exam Form

SEED I Physical Exam Form

QC (yes/no) Name:__________________________ **STUDY ID#_________________**
Gender:_________________________________
Date of Birth: ___________________________ Date of examination: ______________________

Chronological Age:________________________ Examiner: ______________________________

Scale QC - Use object of known weight Record weight here (including units):	Initial Scale reading with object	COMMENTS (Type of object used)

PARENT MEASUREMENTS *(Do not count as a physical anomaly for dysmorphology classification)*

Biological MOTHER	**Measurement** *Note Units*	**Percentile**	**Exam Comments**
Height (can be reported)		n/a	☐ unreliable – reason_______________
Head circumference **(cm)**			☐ unreliable – reason_______________
Biological FATHER	**Measurement** *Note Units*	**Percentile**	**Exam Comments**
Height (can be reported)		n/a	☐ unreliable – reason_______________
Head circumference **(cm)**			☐ unreliable – reason_______________

DYSMORPHOLOGY EXAMINATION

Growth Parameters	**Measurement**	**Percentile**	**Exam Comments**
Height **(cm)**			☐ unreliable – reason__________________________________
Weight **(kg)**			☐ unreliable – reason__________________________________
Head Circumference **(cm)**			☐ unreliable – reason__________________________________

1) **Was [CHILD] born with any problems in the structure of his/her body or organs (also know as birth defects)?**
☐ No
☐ Yes - describe _____________________________________

2) **Has [CHILD] had any corrective surgeries? This includes surgeries to repair findings in the abdominal or genital region (such as hernias)?**
☐ No
☐ Yes - describe _____________________________________

3) **Does [CHILD] have a clinical diagnosis of a genetic syndrome?**

☐ No
☐ Possible Dx*:____________________________
☐ Yes Dx*: _______________________________

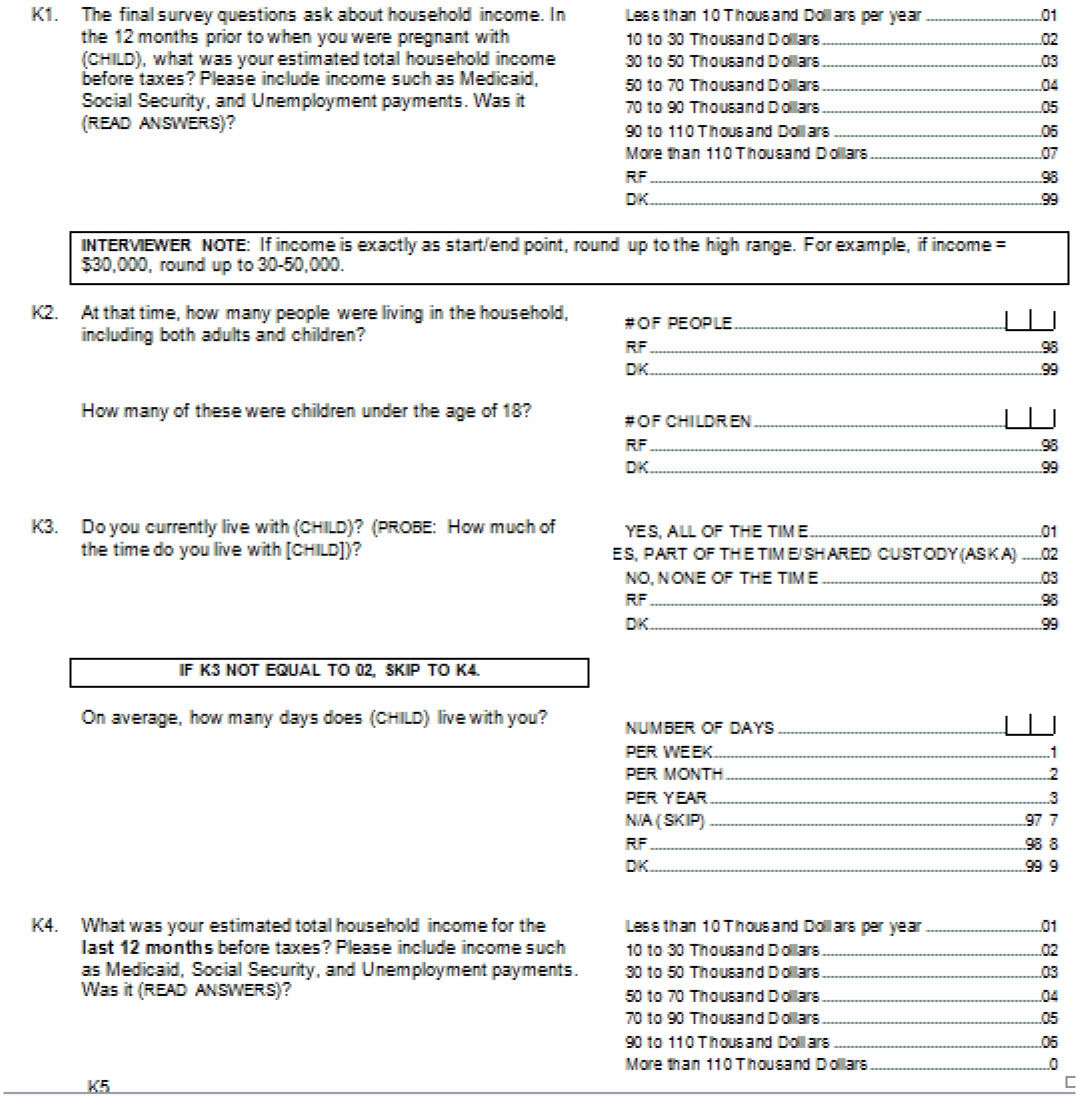
4) **Has [CHILD] had a genetics evaluation, blood tests, or been seen by a genetic counselor?**

☐ No
☐ Yes* Reason/Results:____________________________

(*IF THEY HAVE NOT DONE SO ALREADY, PLEASE BE SURE TO ASK FOR THE FAMILY TO SIGN A HIPAA MEDICAL RECORD RELEASE FOR THIS PROVIDER.)

Appendix D

SECTION K: INCOME AND CLOSING



K1. The final survey questions ask about household income. In the 12 months prior to when you were pregnant with (CHILD), what was your estimated total household income before taxes? Please include income such as Medicaid, Social Security, and Unemployment payments. Was it (READ ANSWERS)?

Less than 10 Thousand Dollars per year	01
10 to 30 Thousand Dollars	02
30 to 50 Thousand Dollars	03
50 to 70 Thousand Dollars	04
70 to 90 Thousand Dollars	05
90 to 110 Thousand Dollars	06
More than 110 Thousand Dollars	07
RF	98
DK	99

INTERVIEWER NOTE: If income is exactly as start/end point, round up to the high range. For example, if income = $30,000, round up to 30-50,000.

K2. At that time, how many people were living in the household, including both adults and children?

# OF PEOPLE	|_|_|
RF	98
DK	99

How many of these were children under the age of 18?

# OF CHILDREN	|_|_|
RF	98
DK	99

K3. Do you currently live with (CHILD)? (PROBE: How much of the time do you live with [CHILD])?

YES, ALL OF THE TIME	01
ES, PART OF THE TIME/SHARED CUSTODY (ASK A)	02
NO, NONE OF THE TIME	03
RF	98
DK	99

IF K3 NOT EQUAL TO 02, SKIP TO K4.

On average, how many days does (CHILD) live with you?

NUMBER OF DAYS	|_|_|
PER WEEK	1
PER MONTH	2
PER YEAR	3
N/A (SKIP)	97 7
RF	98 8
DK	99 9

K4. What was your estimated total household income for the **last 12 months** before taxes? Please include income such as Medicaid, Social Security, and Unemployment payments. Was it (READ ANSWERS)?

Less than 10 Thousand Dollars per year	01
10 to 30 Thousand Dollars	02
30 to 50 Thousand Dollars	03
50 to 70 Thousand Dollars	04
70 to 90 Thousand Dollars	05
90 to 110 Thousand Dollars	06
More than 110 Thousand Dollars	0

K5

K5. At that time, how many people were living in the household, including both adults and children?

OF PEOPLE .... |__|__|
RF 98
DK 99

How many of these were children under the age of 18?

OF CHILDREN .... |__|__|
RF 98
DK 99

K6. I've asked about some things we think might be associated with development. Is there anything, including some of the factors we've already talked about that you think might cause autism or other developmental problems?

YES 01
NO .... (SKIP TO K8) 02
RF .... (SKIP TO K8) 98
DK .... (SKIP TO K8) 99

K7. Can you tell me about those factors?

VERBATIM: ______________________________

____

____

K8. Why did you decide to be in this study?

VERBATIM: ______________________________

____

____

K9. That completes this interview. In case we need to get in touch with you in the future for this study, would you be willing to give us the name, address, and phone number of someone who should always know where you are? This information will be kept separate from your questionnaire. It will be locked except when needed by the research team, and will be destroyed when the study is finished. RECORD CONTACT INFO IN CIS.

IF CIS NOT AVAILABLE:

NAME OF CONTACT:
PREFIX: ☐ Ms. ☐ Mrs. ☐ Mr. ☐ Dr.
First Name: ______________ Last Name: ______________
Street/Apartment: ______________________________
City/State: ______________________________
Home Phone: ______________ Work Phone: ______________
Relationship: ______________________________

In. In closing, we would like to sincerely thank you for your time and effort and your contribution to this important

Appendix E

SECTION B: SOCIODEMOGRAPHICS

I am going to ask you some basic questions about your family background and education.

B1.	DELETED	
B2.	Were you born in the US?	YES .... (SKIP TO B6) .... 01 NO .... 02 RF .... (SKIP TO B6) .... 98 DK .... (SKIP TO B6) 99
B3.	What country were you born in?	COUNTRY: ____________ ☐☐ N/A (SKIP) .... 97 RF .... 98 DK 99
B4.	What year did you come to the US to live?	YEAR .... (SKIP TO B6) .... ☐☐☐☐ N/A (SKIP) .... 9997 RF .... (SKIP TO B6) .... 9998 DK 9999
B5.	How old were you when you came to the US to live?	AGE: YEARS .... ☐☐ AND/OR MONTHS .... ☐☐ N/A (SKIP) .... 97 97 RF .... 98 98 DK 99 99
B6.	What language do you usually speak at home?	ENGLISH .... 01 SPANISH .... 02 OTHER .... (SPECIFY) .... 90 RF .... 98 DK 99
	SPECIFY: ______________________________	☐☐
B7.	Do you consider yourself of Hispanic or Latina origin?	YES .... 01 NO .... (SKIP TO B8) .... 02 RF .... (SKIP TO B8) .... 98 DK .... (SKIP TO B8) 99
	Which Hispanic or Spanish group do you consider yourself a member of? (PROMPT: Mexican, Puerto Rican, Salvadoran, Honduran, Colombian, Peruvian, Guatemalan, Spanish, Central American, South American, etc.?)	GROUP: ____________ ☐☐ N/A (SKIP) .... 97 RF .... 98 DK 99

B8. What is your race? I'm going to read you a list and then please tell me all categories that apply to you. You can select more than one category. READ ANSWERS AND CODE ALL THAT APPLY.

American Indian or Alaska Native	(ASK A)	01
Asian	(ASK B)	02
Black or African American		03
Native Hawaiian or Other Pacific Islander	(ASK B)	04
White		05
RF	(SKIP TO B9)	98
DK	(SKIP TO B9)	99

IF B8 INCLUDES CODE 01, ASK B8A. OTHERWISE, SKIP TO B8B.

What tribe do you consider yourself a member of?

TRIBE: ______________________	☐☐
N/A (SKIP)	97
RF	98
DK	99

IF B8 INCLUDES CODE 02 OR 05, ASK B8B. OTHERWISE, SKIP TO B9.

What is your country of ethnic origin? (PROMPT: Referring to Asian, Native Hawaiian or other Pacific Island countries.)

COUNTRY: ______________________	☐☐
N/A (SKIP)	97
RF	98
DK	99

B9. What was the highest grade or year of school or college that you had completed at the time (CHILD) was born? READ LIST. SELECT ONE.

No formal schooling		01
Less than high school	(ASK A)	02
12 years, completed high school or equivalent		03
1-3 Years of college		04
Completed technical college		05
Associate's degree		06
4 years of college or bachelor's degree		07
Master's degree		08
Advanced degree		09
RF		98
DK		99

IF B9 NOT EQUAL TO 02, SKIP TO B10.

A. How many years of school did you complete?

# OF YEARS	☐☐
N/A (SKIP)	97
RF	98
DK	99

B10. Is that the highest grade or year of school or college you have currently completed?

YES	(SKIP TO B12)	01
NO		02
RF	(SKIP TO B12)	98
DK	(SKIP TO B12)	99

B11.	What is the highest grade or year of school or college that you have currently completed? READ LIST. SELECT ONE.	Less than high school .... (ASK A) .... 02 12 years, completed high school or equivalent........ 03 1-3 Years of college........ 04 Completed technical college........ 05 Associate's degree........ 06 4 years of college or bachelor's degree........ 07 Master's degree........ 08 Advanced degree........ 09 N/A (SKIP)........ 97 RF........ 98 DK........ 99

IF B11 NOT EQUAL TO 02, SKIP TO B12.

A.	How many years of school did you complete?	# OF YEARS........ |__|__| N/A (SKIP)........ 97 RF........ 98 DK........ 99
B12.	The next few questions are about (CHILD)'s biological father. If you do not know (CHILD)'s father, please let me know at this time.	DK FATHER .... (SKIP TO B24) .... 01 KNOWS FATHER........ 02 N/A (SKIP)........ 97 RF .... (SKIP TO B24) 98
B13.	What is (CHILD)'s biological father's birthdate?	DOB........ |__|__| - |__|__| - |__|__|__|__| MM DD YYYY N/A (SKIP)........ 97 97 9997 RF........ 98 98 9998 DK........ 99 99 9999
B14.	Was he born in the US?	YES........ (SKIP TO B18) .... 01 NO........ 02 N/A (SKIP)........ 97 RF .... (SKIP TO B18) .... 98 DK........ (SKIP TO B18) 99
B15.	What country was he born in?	COUNTRY: ________________ |__|__| N/A (SKIP)........ 97 RF........ 98 DK........ 99
B16.	What year did he come to the US to live?	YEAR........ (SKIP TO B18) .... |__|__|__|__| N/A (SKIP)........ 9997 RF........ (SKIP TO B18) .... 9998 DK........ 9999
B17.	How old was he when he came to the US to live?	AGE: YEARS........ |__|__|

B18. What language does he usually speak at home?

ENGLISH 01
SPANISH 02
OTHER .... (SPECIFY) 90
N/A (SKIP) 97
RF 98
DK 99

SPECIFY: ______________________________ ☐☐

B19. Does he consider himself of Hispanic or Latino origin?

YES 01
NO .... (SKIP TO B20) 02
NA (SKIP) 97
RF .... (SKIP TO B20) 98
DK .... (SKIP TO B20) 99

A. Which Hispanic or Spanish group does he consider himself a member of? (PROMPT: Mexican, Puerto Rican, Salvadoran, Honduran, Colombian, Peruvian, Guatemalan, Spanish, Central American, South American, etc.?)

GROUP: ______________________________ ☐☐
N/A (SKIP) 97
RF 98
DK 99

B20. What is his race? I'm going to read you a list and then please tell me all categories that apply to him. You can select more than one category. READ ANSWERS AND CODE ALL THAT APPLY.

American Indian or Alaska Native .... (ASK A) ... 01
Asian .... (ASK B) .. 02
Black or African American 03
Native Hawaiian or Other Pacific Islander ..... (ASK B) ... 04
White 05
N/A (SKIP) 97
RF .... (SKIP TO B21) .. 98
DK .... (SKIP TO B21) .. 99

IF B20 INCLUDES CODE 01, ASK B20A. OTHERWISE, SKIP TO B20B.

A. What tribe does he consider himself a member of?

TRIBE: ______________________________ ☐☐
N/A (SKIP) 97
RF 98
DK 99

IF B20 INCLUDES CODE 02 OR 05, ASK B20B. OTHERWISE, SKIP TO B21.

B. What is his country of ethnic origin? (PROMPT: Referring to Asian, Native Hawaiian or other Pacific Island countries.)

COUNTRY: ______________________________ ☐☐
N/A (SKIP) 97
RF 98
DK 99

B21. What was the highest grade or year of school or college that (CHILD)'s father had completed at the time (CHILD) was born? READ LIST. SELECT ONE.

No formal schooling 01
Less than high school .... (ASK A) 02
12 years, completed high school or equivalent 03
1-3 Years of college 04
Completed technical college 05

IF B21 NOT EQUAL TO 02, SKIP TO B22.

	A. How many years of school did he complete?	# OF YEARS ..... |__|__| N/A (SKIP) ..... 97 RF ..... 98 DK 99
B22.	Is that the highest grade or year of school or college he has currently completed?	YES ..... (SKIP TO B34) ..... 01 NO ..... 02 N/A (SKIP) ..... 97 RF ..... (SKIP TO B34) ..... 98 DK ..... (SKIP TO B34) 99
B23.	What is the highest grade or year of school or college that he has currently completed? READ LIST. SELECT ONE.	Less than high school ..... (ASK A) ..... 02 12 years, completed high school or equivalent ..... 03 1-3 Years of college ..... 04 Completed technical college ..... 05 Associate's degree ..... 06 4 years of college or bachelor's degree ..... 07 Master's degree ..... 08 Advanced degree ..... 09 N/A (SKIP) ..... 97 RF ..... 98 DK 99

IF B23 NOT EQUAL TO 02, SKIP TO B34.

	A. How many years of school did he complete?	# OF YEARS ..... |__|__| N/A (SKIP) ..... 97 RF ..... 98 DK 99

The next few questions are about the family background and education of **any other caregivers** living in the home with (CHILD).

B34.	Do you live with a spouse or partner or other adult who is a primary caregiver of (CHILD) who is **not** (CHILD)'s biological parent?	YES ..... 01 NO ..... (SKIP TO NEXT SECTION) ..... 02 RF ..... (SKIP TO NEXT SECTION) ..... 98 DK ..... (SKIP TO NEXT SECTION) 99
	A. What is that person's relationship to (CHILD)?	STEPMOTHER ..... 01 STEPFATHER 02

B35.	What is (CAREGIVER)'s birthdate?	DOB .... __ __ - __ __ - __ __ __ __ MM DD YYYY N/A (SKIP) .... 97 97 9997 RF .... 98 98 9998 DK 99 99 9999
B36.	Was (CAREGIVER) born in the US?	YES .... (SKIP TO B40) .... 01 NO .... 02 N/A (SKIP) .... 97 RF .... (SKIP TO B40) .... 98 DK .... (SKIP TO B40) 99
B37.	What country was (CAREGIVER) born in?	COUNTRY: ________________ ☐☐ N/A (SKIP) .... 97 RF .... 98 DK 99
B38.	What year did (CAREGIVER) come to the US to live?	YEAR .... (SKIP TO B40) .... __ __ __ __ N/A (SKIP) .... 9997 RF .... (SKIP TO B40) .... 9998 DK 9999
B39.	How old was (CAREGIVER) when (he/she) came to the US to live?	AGE: YEARS .... __ __ AND/OR MONTHS .... __ __ N/A (SKIP) .... 97 97 RF .... 98 98 DK 99 99
B40.	What language does (CAREGIVER) usually speak at home?	ENGLISH .... 01 SPANISH .... 02 OTHER .... (SPECIFY) .... 90 N/A (SKIP) .... 97 RF .... 98 DK 99

SPECIFY: ____ ☐☐

B41.	Does (he consider himself/she consider herself) of Hispanic or (Latino/Latina) origin?	YES .... 01 NO .... (SKIP TO B42) .... 02 N/A (SKIP) .... 97 RF .... (SKIP TO B42) .... 98 DK .... (SKIP TO B42) 99

B42. What is (CAREGIVER)'s race? I'm going to read you a list and then please tell me all categories that apply to (him/her). You can select more than one category. READ ANSWERS AND CODE ALL THAT APPLY.

American Indian or Alaska Native	(ASK A)	01
Asian	(ASK B)	02
Black or African American		03
Native Hawaiian or Other Pacific Islander	(ASK B)	04
White		05
N/A (SKIP)		97
RF	(SKIP TO B43)	98
DK	(SKIP TO B43)	99

IF B42 INCLUDES CODE 01, ASK B42A. OTHERWISE, SKIP TO B42B.

A. What tribe does (he/she) consider (himself/herself) a member of?

TRIBE: ____________ ☐☐

N/A (SKIP)	97
RF	98
DK	99

IF B42 INCLUDES CODE 02 OR 05, ASK B42B. OTHERWISE, SKIP TO B43.

B. What is (his/her) country of ethnic origin? (PROMPT: Referring to Asian, Native Hawaiian or other Pacific Island countries.)

COUNTRY: ____________ ☐☐

N/A (SKIP)	97
RF	98
DK	99

B43. What was the highest grade or year of school or college that (CAREGIVER) had completed at the time (CHILD) was born? READ LIST. SELECT ONE.

No formal schooling		01
Less than high school	(ASK A)	02
12 years, completed high school or equivalent		03
1-3 Years of college		04
Completed technical college		05
Associate's degree		06
4 years of college or bachelor's degree		07
Master's degree		08
Advanced degree		09
N/A (SKIP)		97
RF		98
DK		99

IF B43 NOT EQUAL TO 02, SKIP TO B44.

A. How many years of school did (he/she) complete?

# OF YEARS	☐☐
N/A (SKIP)	97
RF	98
DK	99

IF B43 NOT EQUAL TO 02, SKIP TO B44.

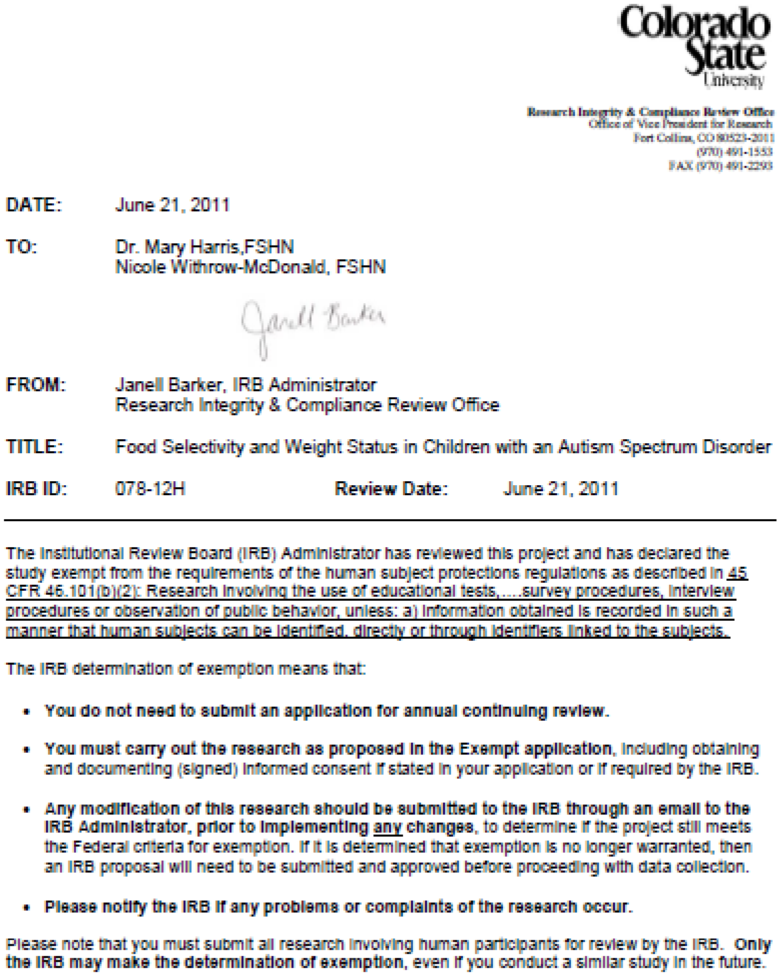
	A. How many years of school did (he/she) complete?	# OF YEARS	☐☐
		N/A (SKIP)	97
		RF	98
		DK	99
B44.	Is that the highest grade or year of school or college (he/she) has currently completed?	YES (SKIP TO NEXT SECTION)	01
		NO	02
		N/A (SKIP)	97
		RF (SKIP TO NEXT SECTION)	98
		DK (SKIP TO NEXT SECTION)	99
B45.	What is the highest grade or year of school or college that (CAREGIVER) has currently completed? READ LIST. SELECT ONE.	Less than high school (ASK A)	02
		12 years, completed high school or equivalent	03
		1-3 Years of college	04
		Completed technical college	05
		Associate's degree	06
		4 years of college or bachelor's degree	07
		Master's degree	08
		Advanced degree	09
		N/A (SKIP)	97
		RF	98
		DK	99

IF B45 NOT EQUAL TO 02, SKIP TO NEXT SECTION.

	A. How many years of school did (he/she) complete?	# OF YEARS	☐☐
		N/A (SKIP)	97
		RF	98
		DK	99

Appendix F

Institutional Review Board Approval



Colorado State University

Research Integrity & Compliance Review Office
Office of Vice President for Research
Fort Collins, CO 80523-2011
(970) 491-1553
FAX (970) 491-2293

DATE: June 21, 2011

TO: Dr. Mary Harris,FSHN
Nicole Withrow-McDonald, FSHN

Janell Barker

FROM: Janell Barker, IRB Administrator
Research Integrity & Compliance Review Office

TITLE: Food Selectivity and Weight Status in Children with an Autism Spectrum Disorder

IRB ID: 078-12H **Review Date:** June 21, 2011

The Institutional Review Board (IRB) Administrator has reviewed this project and has declared the study exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b)(2): Research involving the use of educational tests,….survey procedures, interview procedures or observation of public behavior, unless: a) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects.

The IRB determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**
- **You must carry out the research as proposed in the Exempt application**, including obtaining and documenting (signed) informed consent if stated in your application or if required by the IRB.
- **Any modification of this research should be submitted to the IRB through an email to the IRB Administrator, prior to implementing any changes**, to determine if the project still meets the Federal criteria for exemption. If it is determined that exemption is no longer warranted, then an IRB proposal will need to be submitted and approved before proceeding with data collection.
- **Please notify the IRB if any problems or complaints of the research occur.**

Please note that you must submit all research involving human participants for review by the IRB. **Only the IRB may make the determination of exemption**, even if you conduct a similar study in the future.