Feasibility of a Virtual Group Nutrition Intervention for Adolescents

with Autism Spectrum Disorder

by

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## ABSTRACT

**Background**: Youth with autism spectrum disorder (ASD) have an increased likelihood of being overweight or developing obesity. As children and adolescents with ASD exhibit problematic eating behaviors and may consume more energy-dense foods and fewer fruits and vegetables than typically developing youth, nutrition represents a modifiable obesity risk factor for adolescents with ASD, yet there is a lack of interventions to improve healthy eating and reduce the risk of obesity in this population.

**Purpose**: The purpose of this study was to examine the feasibility, acceptability, and preliminary efficacy of a virtual implementation of BALANCE (Bringing Adolescent Learners with Autism Nutrition and Culinary Education), an 8-week theory-driven nutrition intervention for adolescents with ASD.

**Methods**: Six groups of adolescents (n=27; group size ranged 2-7) diagnosed with ASD and aged 12-20 years participated in the Social Cognitive Theory (SCT) based intervention via Microsoft Teams. Fidelity checklists measured attendance, participation, homework, fidelity, and technical difficulties. Feasibility of assessing outcome measures, including the Block Kids Food Frequency Questionnaire (FFQ), a validated psychosocial survey, and height and weight, was evaluated on response rate, completion, and data quality. Six adolescent focus groups (n=12) and 21 parent interviews were audio-recorded, transcribed, and analyzed for *a priori* and emergent themes regarding intervention acceptability, perceived benefits, and unintended consequences. Height and weight were measured via ruler and scale as virtually instructed by research staff. Wilcoxon signed-ranked tests were used to compare pre- and post-intervention means for

psychosocial determinants of dietary intake, dietary intake, and anthropometric measures.

**Results**: Mean lesson attendance was 88%, participation was 3.5 of 4, homework completion was 51.9%, fidelity was 98.9%, and prevalence of technical difficulties was 0.4 of 2 (no technical difficulties or minor difficulties for all lessons). Baseline response rate was 100% for all outcome measures, with 98.9-100% completion. Post-intervention response rate was 92.6%-96.3%, with 99.5%-100% completion. Data quality was high for 88% of the matched FFQs and 100% of the psychosocial surveys. The intervention was generally acceptable to participants based on the focus groups and interviews with adolescents and their parents. Themes for acceptability included "virtual format," "group setting," "autonomy/independence," "sensory components," "interaction," "reinforcement," and "parent component." Themes for perceived benefits included "diet changes," "healthy weight," "knowledge/awareness," "behavioral skills," "self-efficacy," "outcome expectations," "outcome expectancies," and "other lifestyle changes." "Anxiety/discomfort" during intervention lessons was an emergent theme regarding unintended consequences. Post-intervention means for three of seven psychosocial determinants of dietary intake improved after the 8-week intervention: behavioral strategies ($p=0.010$), self-efficacy ($p<0.001$), and outcome expectations ($p=0.009$). Mean added sugar intake decreased ($p=0.026$), while there was no significant difference in fruit or vegetable intake. BMI percentile ($p=0.013$) and BMI z-score significantly decreased ($p=0.010$).

**Conclusion**: BALANCE was feasible and acceptable to adolescents and parents. The findings suggest that the intervention may improve some psychosocial determinants of dietary intake immediately after the 8-week intervention. The results are also promising regarding added sugar intake and BMI z-score. Future research should examine efficacy of the intervention compared to a control group and include follow-up measures to detect longer-term outcomes.

# CHAPTER I: STATEMENT OF THE PROBLEM

## Background

As one of the fastest growing developmental disabilities, autism spectrum disorder (ASD) is a pressing public health concern that impacts a variety of disciplines. According to the Autism and Developmental Disabilities Monitoring (ADDM) Network, the prevalence of ASD in 8-year-old children was 18.5 per 1,000, or one in 54, during the 2016 surveillance year (Maenner et al., 2020), up from 16.8 per 1,000 in 2014 (Baio et al., 2018) and 14.6 per 1,000 in 2012 (Christensen et al., 2016). Analysis from the Early ADDM indicates similar prevalence rates among 4-year-old children: 15.3 per 1,000 in 2012, 17.0 per 1,000 in 2014 (Christensen et al., 2019), and 15.6 per 1,000 in 2016 (Shaw et al., 2020). While ADDM rates are often interpreted as national rates, there is evidence for heterogeneity across states (Sheldrick & Carter, 2018). The pediatric prevalence of ASD in the US increased by 556% between 1991 and 1997 (Stokstad, 2001), and from fewer than 3 per 10,000 in the 1970s to more than 30 per 10,000 in the 1990s (Blaxill, 2004).

While it is difficult to assess ASD prevalence on a global scale, evidence suggests that the worldwide prevalence of ASD is lower than the prevalence in the US. Globally, the mean coverage for ASD prevalence data in children and adolescents aged 5-17 years is 16.1% (Christensen et al., 2016). A 2012 systematic review of global epidemiological surveys suggests the prevalence of ASD and other pervasive developmental disorders (PDDs) to be 6.2 per 1,000 (Elsabbagh et al., 2012). More recently, the estimated prevalence of ASD was 15 per 1,000 in developed countries (Baxter et al., 2015; Christensen et al., 2016).

Speculation regarding the increasing prevalence of ASD has yielded varied and conflicting explanations. While increased awareness of ASD and broader diagnostic criteria (Elsabbagh et al., 2012; Muhle et al., 2004) seem to explain some of the increase in prevalence, environmental factors, such as air pollutants, pesticides and other endocrine-disrupting chemicals, electromagnetic pollution, and diet modifications, have been noted as possible contributors to the dramatic increase in prevalence in recent decades (Posar & Visconti, 2017). An analysis comparing an Individuals with Disabilities Education Act (IDEA) snapshot with constant-age tracking trend slopes suggests that 75-80% of the increased prevalence in ASD is not due to changing diagnostic criteria (Nevison, 2014). Reported risk factors for ASD include a variety of genetic and environmental factors (Gardener et al., 2011; Lyall et al., 2017; Wang et al., 2017). ASD prevalence has also increased over recent decades in other countries (Bachmann et al., 2018; Blaxill, 2004; Hansen et al., 2015). In Denmark, most of the increase is attributed to changes in reporting practices (Hansen et al., 2015), and in Germany, misdiagnoses are said to account for some of the increase (Bachmann et al., 2018). Based on current evidence, the increasing observed prevalence of ASD may be partly due to increased awareness and changing diagnostic and reporting practices and partly due to increased risk factors. Prior research has found population attributable fractions of 11.8-13% for observable risk factors of preterm birth, small for gestational age, and Cesarean delivery in the US (Schieve et al., 2014).

Children with ASD have an increased likelihood of being overweight or developing obesity compared to typically developing children, with odds of obesity increasing in adolescents with ASD aged 10-17 years (Must et al., 2017). According to a 2019 meta-analysis, children with ASD have 22.2% prevalence of obesity with a 41.1% greater risk of developing obesity compared to typically developing children (Kahathuduwa et al., 2019). Obesity is associated

with an increased risk of several poor health outcomes, including type 2 diabetes (Goran et al., 2003), hypertension (Friedemann et al., 2012), reduced life span (Must et al., 2012), social marginalization (Strauss & Pollack, 2003), and family economic burden (Wang & Dietz, 2002) in typically developing children and adolescents. In youth with ASD, obesity and obesity-related complications pose a threat to independent living, self-care, and quality of life (Curtin et al., 2014).

Numerous dietary and lifestyle factors may be linked to obesity in children with ASD, including dietary intake, physical activity and sedentary behavior, and sleep disturbances (Dhaliwal et al., 2019). As children and adolescents with ASD exhibit an increased prevalence of problematic eating behaviors, such as food selectivity, or consuming a narrow range of foods (Bandini et al., 2010; Marí-Bauset et al., 2014), and consume more energy-dense foods and fewer fruits and vegetables than typically developing children (Sharp et al., 2013), nutrition represents a critical modifiable risk factor for unhealthy weight gain in this population (Dhaliwal et al., 2019).

## Statement of the Problem

Youth with ASD exhibit a range of problematic eating behaviors, including food selectivity (Bandini et al., 2010; Cermak et al., 2010; Marí-Bauset et al., 2014; Schreck et al., 2004; Sharp et al., 2018) and rigidity in mealtime routines (Attlee et al., 2015; Gray et al., 2018; Polfuss et al., 2016). Youth with ASD may also consume more processed, energy-dense foods (Polfuss et al., 2016; Sharp et al., 2013) and fewer fruits and vegetables than youth without ASD (Evans et al., 2012; Sharp et al., 2013; Siddiqi et al., 2019). Such food choices may lead to imbalanced nutrient intake and excess caloric consumption (Hall et al., 2019) and increase the risk of unhealthy weight gain. Furthermore, youth with ASD may be placed on restrictive diets,

such as the gluten/casein-free diet, due to food intolerances, gastrointestinal issues, or caregiver or practioner recommendations (Ristori et al., 2019; Sathe et al., 2017). Problematic eating behaviors, imbalanced dietary intake, and additional dietary restrictions in youth with ASD point to a need for interventions to improve nutrition knowledge and long-term healthy eating habits for this population.

Many nutrition interventions for children with ASD focus on alleviating symptoms of ASD without addressing outcomes related to dietary patterns (Sathe et al., 2017) or managing weight without addressing participants' healthy eating self-efficacy (Healy et al., 2019). Interventions that include adolescents often use samples with a range of disabilities (Healy et al., 2019). These interventions may not adequately target ASD-specific challenges, such as sensory differences (Hazen et al., 2014; Kern et al., 2006; Leekam et al., 2007) and cognitive rigidity during mealtimes (Attlee et al., 2015; Gray et al., 2018; Polfuss et al., 2016).

Weight management interventions with a diet component have included weight-loss diets rather than nutrition education aimed at improving participants' healthy eating self-efficacy, and have recruited samples of adolescents with a range of disabilities rather than targeting those with ASD (Gephart & Loman, 2013; Ptomey et al., 2015). A 2019 systematic review of weight management interventions in youth with ASD found no interventions with ASD-only samples, only one that limited its age group to adolescents (aged 11-18 years) (Ptomey et al., 2015), and six that included a nutrition component (Healy et al., 2019). Adolescence is a critical period for individuals with ASD as they develop skills necessary to take care of their health and well-being and reduce their risk of chronic diseases that can have lifelong impacts. Furthermore, there is a lack of nutrition interventions in adolescents with ASD that examine psychosocial determinants of dietary intake, such as self-efficacy, behavioral skills, and social support.

While researchers have used Social Cognitive Theory (SCT) (Bandura, 1989) to target such factors associated with healthy eating in individuals without ASD (Vilaro et al., 2016), there is a lack of published studies on similar interventions in youth with ASD. This study incorporates SCT constructs and ASD-specific challenges, including abnormal oral sensory processing (Hazen et al., 2014; Kern et al., 2006; Leekam et al., 2007) and rigidity in mealtime routines (Attlee et al., 2015; Gray et al., 2018; Polfuss et al., 2016) to elicit positive behavior change.

Studies of nutrition interventions for youth with ASD have used a range of self-report or parent-report instruments to measure dietary intake (Dreyer Gillette et al., 2014; Sharp et al., 2014; Hinckson et al., 2013; Muldoon & Cosbey, 2018; An et al., 2019) but have not reported collecting data on psychosocial determinants of dietary intake. This study uses measures that have been previously developed and evaluated in typically developing adolescents (Cullen et al., 2008; Dewar et al., 2012) to measure dietary intake and psychosocial determinants of dietary intake, as well as additional lifestyle behaviors.

## Public Health Significance

A virtual intervention is particularly relevant due to the coronavirus disease of 2019 (COVID-19) pandemic. Children, adolescents, and young adults have exhibited changes in eating behaviors and physical activity, as well as weight gain, due to COVID-19 restrictions (Stavridou et al., 2021). Youth with ASD have unique dietary challenges and behavioral obesity risk factors (Dhaliwal et al., 2019) that may be worsened by the pandemic. Times of crisis such as the COVID-19 pandemic highlight the need for virtual interventions to serve adolescents with ASD.

The findings of this study may be translated to public health practice. The intervention may ultimately be disseminated to virtual schools or programs or made available for homeschool practice. Currently, treatment for youth with ASD includes behavioral interventions, such as Applied Behavior Analysis (ABA) and occupational therapy; treatment of associated medical conditions, such as feeding disorders; and medication (Politte et al., 2015). The increased risk of unhealthy eating behaviors and obesity in youth with ASD warrants nutrition services for all youth with ASD, not just those with nutrition-related diagnoses.

Findings from each stage of the research will be disseminated in a range of formats while the intervention is being expanded and tested in multiple settings. Based on findings of the current stage of the research, an executive summary will be drafted and shared with participants and their community network, including schools, local centers for youth with ASD, and their varied stakeholders. Findings will be presented to local private schools for children with disabilities and to the Hillsborough County School Board to encourage consideration of implementation in virtual schools. In the long-term, a website for the intervention will be created so that other adolescents, parents, and teachers have access to the lesson manuals, activities, and handouts.

If the proposed intervention is feasible, there may be substantial policy implications, in that schools and community programs may have the option to adopt a nutrition education curriculum that can be implemented virtually. A long-term goal of this research is to make nutrition services more available and accessible for youth with ASD in the form of a nutrition education curriculum. If youth with ASD do not have access to nutrition services until they are diagnosed with health issues such as feeding disorders, those without diagnoses are left without support to promote positive dietary behavior change.

## Purpose of the Study

The purpose of this study was to examine the feasibility and acceptability of a virtual implementation of BALANCE (Bringing Adolescent Learners with Autism Nutrition and Culinary Education), a theory-driven nutrition intervention for adolescents with ASD. The aims of the study were: (1) assess feasibility of a virtual version of the BALANCE intervention based on fidelity checklists and engagement records and feasibility of virtually administering instruments to assess outcome measures, including psychosocial determinants of dietary intake, dietary intake, physical activity and sedentary behaviors, and anthropometric measures, (2) examine acceptability, perceived benefits, and unintended consequences of the intervention based on feedback from adolescents with ASD and their parents, and (3) determine preliminary efficacy of the intervention as measured by pre- and post-intervention mean differences in psychosocial determinants of dietary intake, dietary intake, and anthropometric measures.

## Research Questions

Research questions for Aim 1:

1. Is the intervention feasible to implement virtually as measured by fidelity checklists and engagement records?
2. Is it feasible to virtually administer the Block Kids Food Frequency Questionnaire (FFQ) (Cullen et al., 2008) and Physical Activity Screener (Drahovzal et al., 2003) and a Social Cognitive Theory-based survey (Dewar et al., 2012) to adolescents with ASD as measured by response rate, completion, and data quality?

Research questions for Aim 2:

1. Is the virtual intervention acceptable to adolescents with ASD and their parents as reported during adolescent focus groups and parent interviews?
2. What are the benefits of the intervention according to adolescents with ASD and their parents as reported during adolescent focus groups and parent interviews?
3. Are there any unintended consequences of intervention participation according to adolescents with ASD and their parents as reported during adolescent focus groups and parent interviews?

Research question for Aim 3:

1. What is the preliminary efficacy of the intervention, as measured by pre- and post-intervention mean differences in psychosocial determinants of dietary intake, dietary intake, and anthropometric measures?

## Definition of Key Terms

**The Autism Behavior Inventory – Short Form (ABI-S)** – a 24-item parent-report scale to assess ASD symptoms and related behaviors of individuals age 3 years to adulthood with sensitivity to short-term changes.

**Autism spectrum disorder (ASD)** – a developmental disorder that affects communication and behavior.

**Bringing Adolescent Learners with Autism Nutrition and Culinary Education (BALANCE)** – an 8-week theory-driven group nutrition intervention that was developed for adolescents with ASD.

**The Block Kids 2004 Food Frequency Questionnaire (FFQ)** – a 77-item questionnaire that asks participants about consumption of various foods over the past week. The target age range for participants is 8-17 years.

**The Block Kids Physical Activity Screener (PAS)** – a 10-item screener that asks about participants' frequency and duration of activities (i.e., physical activity and screen time) over the past 7 days. The target age range for participants is 8-17 years.

**Body mass index (BMI)** – a measure of body fat based on height and weight.

**The Reach, Effectiveness, Adoption, Implementation, Maintenance (RE-AIM) Framework** – a planning and evaluation framework designed to help translate public health research into practice.

**Social Cognitive Theory (SCT)** – a health behavior theory that assumes learning occurs in a social context with dynamic interaction between person, behavior, and environment.

# CHAPTER II: LITERATURE REVIEW

## Behavioral and Environmental Risk Factors for Obesity in Youth with ASD

### Unhealthy Eating Behaviors

**Food selectivity.** Children with ASD exhibit food selectivity, defined as a complete omission of at least one food or food group, or consumption of a narrow range of foods (Bandini et al., 2010; Cermak et al., 2010; Marí-Bauset et al., 2014; Schreck et al., 2004; Sharp et al., 2018). One study mentioned food selectivity as the most frequently parent-reported challenging feeding behavior in children with ASD ages 5-13 years (Thullen & Bonsall, 2017). In a sample of 279 children with ASD aged 2-17 years, 67% omitted vegetables and 27% omitted fruit (Sharp et al., 2018). Food selectivity may be linked to sensory issues (Chistol et al., 2018; Suarez, 2017), and children with ASD who exhibit sensory issues may consume fewer vegetables than those who do not exhibit sensory issues (Chistol et al., 2018).

There is evidence that food selectivity in children with ASD declines with age but does not resolve completely (Bandini et al., 2017; Beighley et al., 2013; Kuschner et al., 2015). One study in youth with ASD aged 2-18 years that found increased food selectivity compared to typically developing youth reported a decline in food selectivity with age (Beighley et al., 2013). Another study examined whether food selectivity changes with age in children with ASD and found that food refusal improved between two time points that were an average of 6.4 years apart (mean age 6.8 years and 13.2 years), but food repertoire, or number of unique foods consumed, did not (Bandini et al., 2017). Although food selectivity has been found to decrease with age in individuals with ASD, there is also evidence that food selectivity persists at an increased

prevalence in adolescents and young adults with ASD compared to typically developing controls (Kuschner et al., 2015).

**Other problematic eating behaviors.** Parents of children with ASD report that their children exhibit a range of additional problematic mealtime behaviors, including rigidity in mealtime routines (Attlee et al., 2015; Gray et al., 2018; Polfuss et al., 2016), fixation on food (Polfuss et al., 2016), difficulties related to mealtime locations (Gray et al., 2018), problems sitting at the table, unwillingness to try new foods (Attlee et al., 2015). Children with ASD also exhibit reduced food acceptance in a controlled laboratory environment compared to typically developing children (Suarez, 2017). In a study examining food refusal in children with ASD compared to typically developing children aged 3-11 years, children with ASD were more likely to refuse foods based on texture/consistency, taste/smell, mixtures, brand, and shape (Hubbard et al., 2014). While feeding problems begin in infancy, and infants with ASD have a less varied diet compared to controls at 15 months of age (Emond et al., 2010), there is evidence for many problematic mealtime behaviors in adolescents with ASD up to age 16-17 years (Attlee et al., 2015; Gray et al., 2018; Polfuss et al., 2016).

**Impact of unhealthy eating behaviors on obesity risk.** Problematic eating behaviors such as food selectivity contribute to obesity risk in youth with ASD through unhealthy dietary patterns (Dhaliwal et al., 2019). Children and adolescents with ASD have a high preference for processed, energy-dense foods (Polfuss et al., 2016) and starches and a low preference for protein (Attlee et al., 2015). There is evidence that children with ASD consume more energy-dense foods (Sharp et al., 2013) and fewer fruits and vegetables than children without ASD (Evans et al., 2012; Sharp et al., 2013; Siddiqi et al., 2019). One study found that children with ASD aged 3-11 years consume more daily servings of sweetened beverages and snack foods and

fewer daily servings of fruit and vegetables than typically developing children (Evans et al., 2012). Despite this evidence, a 2019 meta-analysis found that children with ASD consume more fruit and vegetables than typically developing children, but the authors noted that only three studies were included in the fruit and vegetable intake analysis (Esteban-Figuerola et al., 2019).

Preference for processed or energy-dense foods and reduced intake of fruit and vegetables independently contribute to risk of unhealthy weight gain. Ultra-processed food intake has been associated with negative health outcomes such as elevated lipid profiles in children (Rauber et al., 2015) and higher body fat and obesity in adolescents (Costa et al., 2018), as ultra-processed diets may cause excess caloric consumption (Hall et al., 2019). Fruit and vegetable consumption has been shown to be inversely associated with weight gain (Alinia et al., 2009; Bertoia et al., 2015; Boeing et al., 2012; Ledoux et al., 2011).

**Physical Activity and Sedentary Behavior**

According to an analysis using National Survey of Children's Health (NSCH) 2011-2012 data, children with ASD engage in less physical activity and are more likely to have obesity than children without ASD (Dreyer Gillette et al., 2015). Similarly, an analysis using NSCH 2016-2017 data found that adolescents with ASD tend to engage in less physical activity and are more likely to be overweight or to have obesity than typically developing adolescents (McCoy & Morgan, 2019). A study conducted in children with ASD aged 3-11 years found a discrepancy between parent report and accelerometer physical activity data; no difference in physical activity between ASD and control groups was detected according to accelerometer data, yet parents reported a difference (Bandini et al., 2013). Another study measuring physical activity in adolescents via accelerometry found less physical activity per day in adolescents with ASD compared to typically developing adolescents aged 13-15 years, with no significant association

in participants ages 16-21 years; differences were significant for the full sample (Stanish et al., 2017). Barriers to physical activity in youth with ASD include requiring more supervision than typically developing youth, adults lacking skills necessary to include their children, and youth with ASD having fewer friends or being excluded (Must et al., 2015).

Youth with ASD may also have greater exposure to screen time; according to a 2019 systematic review, 14 of 16 studies reviewed found that children and adolescents with ASD had greater exposure to screen time than control groups (Slobodin et al., 2019). Screen media exposure may contribute to obesity in children and adolescents through reduced physical activity and increased eating while viewing (Robinson et al., 2017). Increased sedentary behavior is a contributing factor to obesity risk in youth with ASD (Dhaliwal et al., 2019).

**Sleep Disturbances**

Children with ASD exhibit sleep disturbances, with 40-80% of individuals with ASD experiencing sleep problems (Cohen et al., 2014). These disturbances may include decreased sleep efficiency, decreased total sleep time, and increased instances of waking after sleep onset (Devnani & Hegde, 2015; Hollway & Aman, 2011) and can impact health, behavior, cognition, and attention (Chen et al., 2006). A study using NSCH 2011-2012 data found that parent-perceived poorer sleep was associated with increased weight status in children with ASD (Dreyer Gillette et al., 2015). Poor sleep, including short sleep duration and shifted sleep schedules, may contribute to obesity risk in childhood (Li et al., 2017; Miller et al., 2015) and adulthood (Fatima et al., 2016; Ogilvie & Patel, 2017). Hypotheses for sleep disturbances in youth with ASD include arousal and sensory dysregulation (Souders et al., 2017).

**Social and Behavioral Impairments**

Diagnostic criteria for ASD include central domains of social communication impairments and restricted interests/repetitive behaviors (American Psychiatric Association, 2013). Additionally, diagnosis of ASD includes behavior related to sensory issues, e.g., hyper- or hypo-responsiveness to sensory input, or abnormal interests in sensory features of their environment (Sharma et al., 2018). Sensory issues, behavioral rigidity, fixation on food, and impaired social skills are among the top ASD-related social and behavioral impairments mentioned by parents in the context of weight-related behaviors (Polfuss et al., 2016).

**Sensory differences.** Individuals with ASD have abnormal oral sensory processing (Hazen et al., 2014; Kern et al., 2006; Leekam et al., 2007) that may improve over time but has been reported in individuals with ASD up to 56 years of age (Kern et al., 2006). Sensory abnormalities in children with ASD may include hypo-responsiveness, hyper-responsiveness, sensory seeking, or enhanced perception (Posar & Visconti, 2017). Children with ASD may exhibit oral seeking, e.g., putting everything in their mouth, or oral defensiveness, e.g., avoiding certain tastes or textures (Cermak et al., 2010).

In relation to food, children with ASD are more likely to report sensory characteristics of food, i.e., texture/consistency or taste/smell, as the basis of food refusal, compared with typically developing children (Hubbard et al., 2014). Sensory differences in children with ASD are correlated with problematic mealtime behaviors, such as unwillingness to try new foods, inflexibility around mealtime routines, and screaming or crying at the table during mealtimes (Zobel-Lachiusa et al., 2015). As unhealthy eating behaviors such as food selectivity and eating fewer vegetables may be linked to sensory abnormalities in children with ASD (Chistol et al.,

2018; Polfuss et al., 2016), sensory differences may contribute to eating habits that can lead to unhealthy weight gain over time.

**Behavioral rigidity.** Restricted and repetitive behaviors (RRBs) characteristic of ASD include preoccupation with restricted interests, repetitive motor mannerisms, routines and rituals that serve no function, and preoccupation with object parts (Leekam et al., 2011). RRBs are commonly related to screen time, e.g., repeatedly watching segments of videos (Kirby et al., 2017). Several characteristics of digital media, such as visual/auditory stimuli and lack of a socialization component, may contribute to problematic interactions with ASD characteristics, such as sensory differences and social communication deficits (Lane & Radesky, 2019). For instance, children with ASD spend more time playing video games than typically developing children or children with other disabilities (Mazurek et al., 2012; Mazurek & Engelhardt, 2013). Additionally, RRBs may present as fixation on food, i.e., increased appetite or focus on food (Polfuss et al., 2016). RRBs that contribute to either increased sedentary behavior or increased caloric intake may impact risk of unhealthy weight gain in children with ASD.

**Social impairments.** Children with ASD exhibit social impairments, which may include limited social interaction and visual communication (Sharma et al., 2018). Along with problematic eating behaviors such as food selectivity and difficulty sitting at the table, social impairments may limit opportunities for family engagement at mealtime (Suarez et al., 2014). The family environment is a key factor in determining children's long-term dietary patterns (Scaglioni et al., 2018), and parent modeling plays a critical role in children's food choices (Perez-Cueto, 2019).

Social impairments may also contribute to increased sedentary behavior. Nationally representative data from the National Longitudinal Transition Study-2 (NLTS2) indicate that

64.2% of youth with ASD use non-social media, i.e., television and video games (Mazurek et al., 2012). Parents of children with ASD have attributed impaired social skills, such as a reduced ability to communicate in a social setting, to increased time spent on sedentary activities, such as computer/tablet use or playing video games (Polfuss et al., 2016).

### Environmental Challenges

Environmental factors associated with childhood obesity include school policies and parents' work-related demands (Sahoo et al., 2015). One potentially modifiable environmental risk factor for obesity is food environment, or access and availability of food in and outside the home (Mattes & Foster, 2014). Family food environment factors, such as parent feeding strategies, have been associated with food consumption and obesity in childhood (Boswell et al., 2019; Yee et al., 2017). Additionally, external food environments, including schools and restaurants, have been identified as priority areas for childhood obesity intervention (Penney et al., 2014). In addition to environmental factors associated with dietary behaviors in typically developing youth, youth with ASD may face additional environmental challenges, including difficulties related to mealtime locations, such as difficulty eating at restaurants or at school (Gray et al., 2018; Provost et al., 2010).

## Impact of Obesity on Health Outcomes in Youth with ASD

Obesity may contribute to new health issues or exacerbate existing conditions in youth with ASD (Kahathuduwa et al., 2019). In addition to risks associated with obesity in typically developing children and adolescents, such as type 2 diabetes (Goran et al., 2003), hypertension (Friedemann et al., 2012), reduced life span (Must et al., 2012), social marginalization (Strauss & Pollack, 2003), and family economic burden (Wang & Dietz, 2002), those with ASD may face a uniquely significant threat to independent living, overall health and well-being, and quality of

life due to ASD-specific dietary and lifestyle behaviors and social and behavioral impairments (Curtin et al., 2014).

**Nutrient Deficiencies**

While the pathway/relationship between obesity and food selectivity in the development of nutrient deficiencies is unclear, there is evidence for obesity being linked to nutrient deficiencies in the general population, and dietary patterns resulting from food selectivity may contribute to unhealthy weight gain in youth with ASD (Dhaliwal et al., 2019). Despite individuals with obesity consuming excess calories, micronutrient deficiency rates are high in individuals with obesity (Via, 2012). Prior to bariatric weight loss surgery, candidates for surgery have greater risk for micronutrient malnutrition due to frequency of poor nutrition quality in spite of high caloric density of their diets (Frame-Peterson et al., 2017).

In a review of electronic medical records over a 24-month period, severe food selectivity was not associated with compromised growth or obesity in children with ASD (Sharp et al., 2018), yet in another study children with ASD with selective eating were more likely to be at risk for at least one nutrient deficiency (Zimmer et al., 2012). Food selectivity in youth with ASD has been linked to nutrient deficiencies, including vitamin C deficiency and scurvy (Cole et al., 2011; Ma et al., 2016; Rafee et al., 2019), vitamin A deficiency (McAbee et al., 2009), and vitamin D deficiency (Stewart & Latif, 2008). One case of vitamin C deficiency led to invasive interventions and high social, emotional, and economic costs (Rafee et al., 2019), and multiple other cases led to diagnoses of scurvy (Cole et al., 2011; Ma et al., 2016; Saavedra et al., 2018). In one case study, a 10-year-old male with ASD who ate only hamburgers, Wheat Chex®, Pop Tarts®, oyster crackers, and pancakes was diagnosed with scurvy (Cole et al., 2011). In the case of vitamin A deficiency, there was permanent vision loss and optic atrophy (McAbee et al.,

2009), and the case of vitamin D deficiency resulted in nutritional rickets (Stewart & Latif, 2008).

**Oral and Bone Health**

Children with obesity may be at increased risk for poor oral and bone health (Farr & Dimitri, 2017; Lifshitz et al., 2016; Manohar et al., 2019). Excess fat accumulation during childhood may increase risk of fractures (Farr & Dimitri, 2017), and obesity and central adiposity are associated with increased risk of gingivitis (Lifshitz et al., 2016) and dental caries (Manohar et al., 2019).

The impact of obesity on oral and bone health is of particular concern for youth with ASD, who may have an increased risk of poor oral and bone health (Barnhill et al., 2019; Marshall et al., 2010; Neumeyer et al., 2017; Neumeyer et al., 2018). Youth with ASD aged 2-19 years are at a greater risk for dental caries (Marshall et al., 2010). One study in dental patients with ASD (mean age 13.5 years) found that 41% of the patients preferred soft, sweet, or sticky foods (Klein & Nowak, 1999). A recent review indicated that individuals with ASD have reduced bone mineral density (BMD) compared to individuals without ASD (Barnhill et al., 2019). Lower BMD z-scores have been reported at lumbar spine, femoral neck, total hip, and whole body less head in males with ASD aged 8-14 years compared to typically developing controls (Neumeyer et al., 2018), and males with ASD also exhibited impaired bone microarchitectural parameters (mean age with ASD 13.6 years and mean age without ASD 14.2 years) (Neumeyer et al., 2017).

**Altered Gut Microbiome**

Although a causal relationship has not been established, there is evidence for an association between the gut microbiome and obesity (Maruvada et al., 2017). At the same time,

gastrointestinal problems in individuals with ASD have been connected to altered gut microbiome, with implications for brain development (Fowlie et al., 2018). Gut microbial imbalance (dysbiosis) may contribute to the progression of health conditions, including inflammatory bowel disease, celiac disease, obesity, colorectal cancer, and ASD (Kho & Lal, 2018). While associations have been established between the gut microbiome and obesity and the gut microbiome and ASD, it is unclear how these associations impact each other.

### Long-Term Health Outcomes

Research on long-term health outcomes of obesity in individuals with ASD is lacking, but long-term health outcomes of obesity in the general population are well-known and include cardiovascular disease, obesity-related cancers, type 2 diabetes, osteoarthritis, and psychological disturbance (Dixon, 2010). Children with obesity are more likely to suffer from obesity as adults and to suffer from chronic diseases such as type 2 diabetes, cardiovascular disease, and cancer (Llewellyn et al., 2016). Dealing with such outcomes may be especially burdensome for individuals with ASD who already experience high costs of education and medical and alternative therapies (Rogge & Janssen, 2019). As adults with ASD face similar dietary and physical activity challenges to children with ASD (Garcia-Pastor et al., 2019; Kuschner et al., 2015), contributing to an increased prevalence of obesity (Croen et al., 2015), lifestyle behavior interventions may help to prevent negative long-term health outcomes in this population.

## Nutrition Interventions in Youth with ASD

Two literature reviews were conducted to examine the effectiveness of nutrition interventions to improve diet or reduce obesity in children and adolescents with ASD. Inclusion and exclusion criteria for the reviews are detailed in Table 1. Due to a lack of studies in adolescents with ASD, interventions with samples of adolescents with developmental and/or

intellectual disabilities were included if ASD was explicitly mentioned in descriptions of the sample. For these studies, 36-53% of the sample had ASD.

**Table 1. Inclusion and exclusion criteria for nutrition interventions in youth with autism spectrum disorder**

| Inclusion Criteria | | Exclusion Criteria | |
|---|---|---|---|
| **Search 1** | **Search 2** | **Search 1** | **Search 2** |
| -Population of children with ASD<br>-Intervention component<br>-Outcomes related to improving diet (e.g., diet variety, diet quality, nutrient intake) and/or body composition/weight | -Population of children with disabilities, including ASD<br>-No intervention component<br>-No outcomes related to improving dietary patterns (e.g., diet variety, nutrient intake, diet quality) and/or body composition/weight<br>-Not available in English | -Sample included adolescents with ASD aged 10-19 years<br>-Intervention component<br>-Outcomes related to dietary intake and/or body composition/weight | -No intervention component<br>-Sample included adolescents with disabilities, but ASD was not specifically mentioned<br>-Age group did not include any age within the 10-19-year range<br>-Not available in English |

Fourteen studies met the criteria for the two-part literature review (Ahearn, 2003; An et al., 2019; Cassey et al., 2016; Cosbey & Muldoon, 2017; Dreyer Gillette et al., 2014; Hinckson et al., 2013; Marshall et al., 2015; Miyajima et al., 2017; Muldoon & Cosbey, 2018; Panerai et al., 2018; Pona et al., 2017; Ptomey et al., 2015; Sharp et al., 2014; Tanner & Andreone, 2015). The seven studies with samples limited to children 8 years and younger involved interventions to improve feeding difficulties. Three studies used Applied Behavior Analysis (ABA) methods (Marshall et al., 2015; Panerai et al., 2018; Tanner & Andreone, 2015). The single case experimental study with one participant used a 12-step graduated exposure technique (Tanner & Andreone, 2015). One study used contingency management and other principles stemming from ABA (Panerai et al., 2018). Two studies used systematic desensitization, i.e., graduated exposure

therapy (Marshall et al., 2015; Tanner & Andreone, 2015), and one compared systematic desensitization to operant conditioning (Marshall et al., 2010). Other approaches included evidence-based parent-training (Cosbey & Muldoon, 2017) and an intervention informed by the Person Environment Occupation (PEO) model (Miyajima et al., 2017). All studies involved evidence-based training curricula designed to increase the number of foods consumed in children with ASD. The study with one adolescent participant also aimed to improve feeding difficulties; the intervention involved simultaneous presentation of nonpreferred foods with condiments to increase the consumption of nonpreferred foods (vegetables) (Ahearn, 2003).

All six interventions with BMI outcomes conducted in adolescent samples consisted of comprehensive interventions, including a weight management clinic (Dreyer Gillette et al., 2014), a hospital-based clinical treatment program (Pona et al., 2017), and other comprehensive programs with dietary components (Gephart & Loman, 2013; Hinckson et al., 2013; Ptomey et al., 2015), including a 14-week school-based intervention based on the national health promotion model I Can Do It! (An et al., 2019). The other group intervention consisted of a game, Good Nutrition Game, in which participants earned points for eating a bite of fruit or vegetables (Cassey et al., 2016).

**Study Designs and Participants**

The nine studies conducted with samples consisting exclusively of youth with ASD (and a control group where relevant) include a multiple baseline design, two randomized-controlled trials (RCTs), three single case experimental designs (SCEDs), one pilot trial, and two quasi-experimental studies. The multiple baseline study was conducted with one 14-year-old male with ASD (Ahearn, 2003). One RCT was conducted with 10 families of children with ASD aged 3-8 years and a waitlist control of nine families (Sharp et al., 2014), and the other RCT was

conducted with children with ASD aged 2-6 years with a control group of children with a nonmedically complex history (n=68) to compare operant conditioning and systematic desensitization interventions (Marshall et al., 2015). The SCEDs were conducted with one 3.5-year-old male with ASD (Tanner & Andreone, 2015), three families of males with ASD aged 6-8 years (Cosbey & Muldoon, 2017), and four adolescents with ASD aged 14-19 years (Cassey et al., 2016). The pilot trial was conducted with 23 parents of children with ASD aged 3-6 years (Miyajima et al., 2017). One quasi-experimental study was conducted in eight children with ASD and 10 children with intellectual disability (Panerai et al., 2018) and the other quasi-experimental study was conducted with three families of males with ASD aged 3-5 years (Muldoon & Cosbey, 2018).

There were five studies conducted in heterogeneous samples: three cohort studies, one RCT, and one SCED. One cohort study was conducted in 17 adolescents aged 7-20 years, with 41% of the sample having ASD (Hinckson et al., 2013). The other two cohort studies had wide age ranges; one was conducted with 30 children aged 2-19 years, with 53% having ASD (Dreyer Gillette et al., 2014), and the other was conducted with 115 children aged 2-18 years, with 51% having ASD (Pona et al., 2017). The RCT included 20 adolescents aged 11-18 years, with 45% of the sample having ASD (Ptomey et al., 2015). The SCED was conducted in 14 adolescents aged 12-15 years, with 36% having ASD (An et al., 2019).

**Outcomes and Measures**

The most common dietary outcome was number of food items consumed, i.e., "food repertoire," "diet variety," or "dietary diversity," mentioned by seven studies (Cosbey & Muldoon, 2017; Dreyer Gillette et al., 2014; Marshall et al., 2015; Miyajima et al., 2017; Muldoon & Cosbey, 2018; Panerai et al., 2018; Sharp et al., 2014; Tanner & Andreone, 2015).

Five studies examined number of food items consumed from specific food groups, e.g., fruit and vegetables, three studies examined fruit and vegetable intake (An et al., 2019; Cassey et al., 2016; Marshall et al., 2015), one measured vegetable consumption only (Ahearn, 2003), and one assessed frequency of consumption of breakfast, carbonated drinks, white bread, whole grains, confectionary, and cooked fresh food (Hinckson et al., 2013). The RCT that measured fruit and vegetable intake also examined unprocessed fruit and vegetable intake and empty-calorie food intake (Marshall et al., 2015). One study included water intake as an outcome (An et al., 2019).

Other dietary outcomes included nutrient intake and diet quality. The RCT that examined intake of fruit and vegetables, unprocessed fruit and vegetables, and empty-calorie foods also examined nutrient intake for 21 nutrients, percent energy intake, and carbohydrate and protein intake (Marshall et al., 2015) One study measured energy intake and diet quality using the Healthy Eating Index-2010 (HEI-2010) (Ptomey et al., 2015).

Seven studies reported anthropometric outcomes, including BMI (Hinckson et al., 2013; Marshall et al., 2015; Ptomey et al., 2015), BMI z-score (An et al., 2019; Dreyer Gillette et al., 2014; Pona et al., 2017), waist circumference (An et al., 2019; Hinckson et al., 2013; Ptomey et al., 2015), and body weight (Panerai et al., 2018). Three measured physical activity related outcomes (An et al., 2019; Hinckson et al., 2013; Ptomey et al., 2015). Intervention acceptability was measured in three studies (Cosbey & Muldoon, 2017; Hinckson et al., 2013; Muldoon & Cosbey, 2018). Other outcomes of the studies are not reported in this review.

Quantitative data were collected for all dietary, physical activity, and body composition or weight related outcomes. In several cases, observation was used to collect quantitative data on dietary intake, including structured observation for a 3-day weighed food diary in an outpatient clinic (Marshall et al., 2015) and participation observation to determine number of foods

consumed (Miyajima et al., 2017; Panerai et al., 2018) or bites or pieces of food consumed (Ahearn, 2003; Cassey et al., 2016; Cosbey & Muldoon, 2017; Tanner & Andreone, 2015). Other studies used self-report or parent-report instruments, including a modified Food Preference Assessment (Dreyer Gillette et al., 2014), Food Preference Inventory (FPI) (Sharp et al., 2014), a 14-item nutrition questionnaire (Hinckson et al., 2013), parent-reported 24-hour food recall questionnaire, (Muldoon & Cosbey, 2018), and self-reported fruit and vegetable and water intake via checkboxes (An et al., 2019).

Of the three studies that measured physical activity, two successfully used self/parent report. The study in 12-15-year-olds used self-reported daily average exercise minutes and weekly physical activity frequency, with additional monitoring from intervention mentors, classroom teachers, and paraprofessionals (An et al., 2019). The cohort study in adolescents aged 7-20 years measured physical activity by questionnaire with questions modified from the "Mind, Exercise, Nutrition…Do It!" (MEND) program questionnaire (Sacher et al., 2010) and physical fitness through a six-minute walk test (Hinckson et al., 2013). The RCT conducted with 11-18-year-olds measured physical activity by accelerometry (Ptomey et al., 2015).

Among studies that reported equipment to measure height and weight, either wall-mounted Accurate Technology, Inc. stadiometer (Dreyer Gillette et al., 2014; Pona et al., 2017) or portable stadiometer (Ptomey et al., 2015) was used to measure height, and either Scale-Tronix digital scale (Dreyer Gillette et al., 2014; Pona et al., 2017) or Befour PS6600 digital scale was used to measure weight (Ptomey et al., 2015). In some cases, qualitative data were collected on intervention acceptability using semi-structured interviews with parents, teachers, and program leaders (Hinckson et al., 2013) or parent questionnaire (Cosbey & Muldoon, 2017; Muldoon & Cosbey, 2018; Sharp et al., 2014).

**Analyses**

Statistical analysis methods were diverse. The RCT of a parent-training curriculum to address feeding problems in children aged 3-8 years, Autism MEAL Plan, conducted an analysis of variance (ANOVA) on pre-intervention dependent measures and an analysis of covariance (ANCOVA) on post-intervention scores between intervention and control groups, as well as descriptive characteristics for pre- and post-intervention scores for both groups (Sharp et al., 2014). The RCT comparing operant conditioning and systematic desensitization interventions in children aged 2-6 years used a univariable linear regression model to calculate pre- and post-intervention scores, and effect sizes were calculated for pre-post comparisons (Marshall et al., 2015). The RCT comparing Enhanced Stop Light Diet (eSLD) or conventional diet + physical activity in adolescents aged 11-18 years used bivariate analyses; general mixed modeling for group, time, and group-by-time interaction effects on accelerometry variables; and general linear modeling for other outcome group effects with age, sex, race, level of intellectual or developmental disability severity (Ptomey et al., 2015).

The cohort study of a comprehensive program in adolescents aged 7-20 years used paired t-tests using Hopkins' spreadsheet (Hopkins, 2006), adjusting data for age due to wide age ranges (Hinckson et al., 2013). The cohort study of a comprehensive program in children aged 2-19 years used paired t-tests to measure change in BMI z-score and food preferences and Pearson correlations and ANOVA to examine whether demographic variables, baseline BMI z-score, and attendance were related to change in BMI z-score (Dreyer Gillette et al., 2014). The cohort study of a comprehensive program in 115 children aged 2-18 years used multilevel modeling to test change in BMI z-score between baseline and 12-month follow-up (Pona et al., 2017).

The SCED study of a train-the-trainer, family-centered feeding intervention, Easing Anxiety Together with Understanding and Perseverance (EAT-UP), in three families and its follow-up study used visual analysis (description of trends), measure of effect size, and qualitative analysis of parent surveys (Cosbey & Muldoon, 2017; Muldoon & Cosbey, 2018). The SCED of a school-based intervention in adolescents aged 12-15 years used Chi-square tests for pre- and post-intervention scores and repeated measures ANCOVA for pre- and post-scores adjusted for sex, as well as descriptive statistics (An et al., 2019). The quasi-experimental study of a multidisciplinary intervention used the Wilcoxon test for paired data sets for pre- and post-treatment assessments (Panerai et al., 2018). The pilot trial measured differences two months before and two months after the intervention using one-way ANOVA or the Friedman test, as appropriate (Miyajima et al., 2017). The only qualitative analysis method mentioned was thematic analysis (Morse & Field, 1995) to analyze interview data (Hinckson et al., 2013).

**Efficacy**

Among the seven studies limited to children ages 2-8 years, six reported an increase in foods consumed (Cosbey & Muldoon, 2017; Marshall et al., 2015; Miyajima et al., 2017; Muldoon & Cosbey, 2018; Panerai et al., 2018; Tanner & Andreone, 2015). One SCED reported an increase in food repertoire from four items to over 50 items (Tanner & Andreone, 2015). The pilot trial from Japan reported an increase in number of foods consumed by 4.35 ($p=0.004$) and a decrease in number of unaccepted foods by 2.73 ($p<0.001$) from a list of 47 foods, as well as a decrease in parents' subjective view of dietary imbalance ($p<0.001$) (Miyajima et al., 2017). Another study reported an average of 14 foods added to the child's food repertoire and an increase in food acceptance ($d$ >0.90) (Cosbey & Muldoon, 2017), and the second phase of the same study reported an increase in food acceptance with a qualitative description of increased

food acceptance and diet diversity (Muldoon & Cosbey, 2018). The study from Italy reported increased food acceptance and texture variety but did not test for significance within the group of children with ASD (Panerai et al., 2018). The RCT that compared operant conditioning and systematic desensitization reported the full sample's baseline to 3-month follow-up, including an increase in number of foods consumed ($p<0.01$), as well as significant improvements in micronutrient, percent energy, protein, fruit and vegetable, unprocessed fruit and vegetable, and empty-calorie food intake (Marshall et al., 2015). The other RCT found no change in feeding behaviors or diet variety but found a significant decrease in parent stress compared to the control group ($p=0.01$) (Sharp et al., 2014).

Among studies including adolescents, all three studies examining fruit and vegetable consumption reported increased consumption (Ahearn, 2003; An et al., 2019; Cassey et al., 2016), and the one study that examined diet variety reported increased variety of fruit, vegetables, and grains (Dreyer Gillette et al., 2014). Bites consumed were increased for both studies that measured bites of fruit and vegetables consumed (Ahearn, 2003; Cassey et al., 2016). In the simultaneous presentation study, vegetable consumption was increased to 100% for each food item when ketchup was added (Ahearn, 2003). The Good Nutrition Game study found that bites of fruit and vegetables consumed increased by a mean of 6.2 bites across the four participants (Cassey et al., 2016). In the school-based intervention for adolescents with intellectual and developmental disabilities, intake significantly increased from 7% to 86% of the sample consuming fruit and vegetable every day (An et al., 2019). The comprehensive weight management clinic that examined diet variety found variety of fruit, vegetables, and grains to be significantly increased at the 6-month follow-up ($p<0.01$, $p=0.02$, $p=0.03$, respectively) (Dreyer Gillette et al., 2014).

Of the eight studies examining weight-related outcomes, four found BMI or weight to be significantly reduced (Gephart & Loman, 2013; Dreyer Gillette et al., 2014; Pona et al., 2017; Ptomey et al., 2015). The RCT found 3.3% and 4.6% decreases in body weight for the two diets used (Ptomey et al., 2015). The controlled clinical trial found a significant decrease in mean BMI percentile of 2.93% ($p<0.01$) (Gephart & Loman, 2013). One cohort study found a significant decrease in mean BMI z-score from 2.43 to 2.36 ($p<0.01$) (Dreyer Gillette et al., 2014), and another found BMI z-scores to be significantly reduced by 0.02 per month, controlling for age and baseline BMI z-score (Pona et al., 2017). The other two studies found no change in BMI or body composition (An et al., 2019; Hinckson et al., 2013). BMI and body weight slightly increased but not significantly in the two studies of young children that measured weight-related outcomes (Marshall et al., 2015; Panerai et al., 2018).

**Discussion**

All studies reviewed with samples limited to children with ASD aged 8 years and younger, as well as the study in one 14-year-old male, aimed to improve feeding difficulties such as selective eating. Of the interventions conducted in samples of children with disabilities including ASD, four were weight management interventions and the other was a health promotion intervention. The one study with a sample size greater than one that consisted entirely of adolescents with ASD aimed to promote healthy eating habits.

Interventions conducted in heterogeneous samples may not address ASD-specific issues such as sensory differences and behavioral rigidity. The Good Nutrition Game intervention was the only ASD-specific intervention that aimed to increase nutritious food consumption rather than improve feeding difficulties. Although these goals may be overlapping, there is a need for interventions that encourage long-term healthy eating in children and adolescents with ASD in

addition to helping those who may be at-risk for or diagnosed with feeding difficulties. Furthermore, the only two interventions conducted in ASD-only samples measuring weight-related outcomes found BMI and weight to be slightly increased (the interventions aimed at improving feeding difficulties rather than improving healthy eating habits or weight outcomes). The potential impact of healthy eating interventions on weight-related outcomes in children with ASD is largely unknown.

Nutrition interventions in children and adolescents with ASD had diverse intervention designs, objectives, outcomes, and measures. Although all but one study included dietary outcomes, less than half examined specific food or food group intake (e.g., fruit and vegetable intake), only one study examined nutrient intake (Marshall et al., 2015), and only one examined diet quality (Ptomey et al., 2015). Moreover, there is a lack of nutrition interventions in adolescents with ASD that focus on environmental factors, such as social support, barriers, and opportunities. Social Cognitive Theory (SCT) (Bandura, 1989) has been frequently used to improve personal, behavioral, and environmental factors associated with healthy eating in individuals without ASD (Vilaro et al., 2016). However, nutrition education interventions for typically developing adolescents do not address ASD-specific challenges, such as sensory issues or cognitive rigidity. One weight-loss intervention for adolescents with intellectual and developmental disabilities included lifestyle modification sessions focused on social support, self-monitoring, and self-efficacy (Ptomey et al., 2015), but only 9 of the 20 participants were diagnosed with ASD, and a specific theory was not mentioned even though constructs of SCT were measured. Research on interventions to encourage healthy eating habits in children and adolescents with ASD that address ASD-specific eating challenges, including abnormal oral

sensory processing (Hazen et al., 2014; Kern et al., 2006; Leekam et al., 2007) and rigidity in mealtime routines (Attlee et al., 2015; Gray et al., 2018; Polfuss et al., 2016) are needed.

### Virtual Nutrition Interventions for Typically Developing Youth

While there is a lack of online nutrition education interventions for youth with ASD, many online nutrition education interventions have been conducted in typically developing youth. A 2016 review of online nutrition education interventions for children aged 5-13 years identified three types of nutrition education interventions for children: platforms to communicate with peers or professionals, platforms with nutrition education through a web tool, and platforms with nutrition education through a web tool with automated feedback (Domínguez Rodríguez et al, 2016). A 2014 systematic review of computer-mediated, obesity-related nutrition education interventions for adolescents aged 12-18 years noted that interventions included elements such as email counseling, gender-specific interfaces, multimedia interaction, and computer-tailored feedback as methods to ensure adherence and engagement (Ajie & Chapman-Novakofski, 2014). Types of online nutrition education interventions for children and adolescents included internet-based or CD-ROM programs, with some being conducted in school settings (Ajie & Chapman-Novakofski, 2014; Domínguez Rodríguez et al, 2016).

Online nutrition education interventions for children and adolescents have been associated with a range of positive nutrition- and obesity-related outcomes (e.g., Au et al., 2016; Chen et al., 2011; Di Noia et al., 2008; Grimes et al., 2018). Nutrition-related outcomes include knowledge, attitudes, and behaviors related to specific foods or meals, such as fruit and vegetables (Chen et al., 2011; Di Noia et al., 2008), breakfast (Au et al., 2016), and salt (Grimes et al., 2018), as well as the home food environment (Cullen et al., 2017). Potential mediating variables that may impact intervention outcomes include intervention duration, participation,

setting, theory, skill-building strategies, parental involvement, and gender (Ajie & Chapman-Novakofski, 2014).

Factors contributing to successful online nutrition education interventions include tailored messaging and feedback, application of health behavior theory (Ajie & Chapman-Novakofski, 2014; Murimi et al., 2019), specific behavior identification, participant-investigator interaction, and alignment between objectives and activities (Murimi et al., 2019). Study design and implementation issues include comparison bias, lack of follow-up, lack of specific details such as dose, lack of tracking engagement, and limited use of objective measurement due to the need for self-reported measures (Murimi et al., 2019; Olson, 2017). As there is potential to elicit greater behavior change in adolescents compared to traditional didactic intervention programs (Casazza & Ciccazzo, 2006), online nutrition education interventions for adolescents that build on previous research are warranted.

## Summary of the Literature

There is a lack of research on interventions to improve healthy eating habits in adolescents with ASD. It is known that children with ASD have unhealthy eating behaviors (Marí-Bauset et al., 2014; Sharp et al., 2013) and are influenced by ASD-specific social and behavioral impairments (American Psychiatric Association, 2013), as well as reduced physical activity (Dreyer Gillette et al., 2015) and sleep disturbances (Cohen et al., 2014). These behaviors may continue into adolescence or adulthood, contributing to imbalanced nutrient and food group intake (Sharp et al., 2013) and an increased risk of obesity and obesity-related health outcomes (Kahathuduwa et al., 2019).

Existing nutrition interventions for youth with ASD aim to improve feeding difficulties, such as food selectivity, rather than healthy eating habits (Sharp et al., 2014; Tanner &

Andreone, 2015). Many of these studies have been conducted in children aged 8 years and younger (Marshall et al., 2015; Miyajima et al., 2017; Muldoon & Cosbey, 2018, 2018; Sharp et al., 2014; Tanner & Andreone, 2015). Nutrition interventions that include adolescents with ASD address healthy eating behaviors but also include adolescents with other disabilities and do not address ASD-specific issues, such as cognitive rigidity and sensory differences (An et al., 2019; Dreyer Gillette et al., 2014; Hinckson et al., 2013; Pona et al., 2017; Ptomey et al., 2015). Although online nutrition education interventions have not been implemented in youth with ASD, such interventions show promise for improving dietary behaviors in typically developing youth (Ajie & Chapman-Novakofski, 2014; Domínguez Rodríguez et al, 2016). There is a need for similar nutrition interventions to improve long-term healthy eating behaviors in adolescents with ASD.

## Theoretical Framework

The Institute of Medicine recommends the Social Ecological Model (SEM) to examine determinants of childhood obesity and provide a foundation for intervention research (Institute of Medicine (US) Committee on Prevention of Obesity in Children and Youth, 2005). The SEM is a comprehensive, multilevel framework that focuses on connections between individuals and their physical and sociocultural environments (Stokols, 1992). The SEM posits that all levels of influence play a role in shaping health behaviors. The SEM includes individual (knowledge, attitudes, skills), interpersonal (families, friends, social networks), organizational (organizations, social institutions), community (relationships between organizations), and policy (state and local laws and regulations) levels. Some ecological models are tailored to specific health behaviors or behaviors and environmental attributes, e.g., a complementary ecological model of the coordinated school health program (CSHP) (Lohrmann, 2008), while others focus on specific

levels of the SEM, e.g., Theory of Planned Behavior focuses on the individual level (Fishbein, 1967).

As food choice is a complex behavior (Sobal & Bisogni, 2009), and there is a lack of research measuring psychosocial determinants of dietary intake in youth with ASD, the current study aims to better understand the feasibility and acceptability of a novel nutrition education intervention in this population. Social ecological theories, such as Social Cognitive Theory, Theory of Planned Behavior, and community engagement, have frequently been applied to nutrition and/or obesity prevention interventions for typically developing individuals. While multiple levels of the SEM may be needed to adequately address obesity risk in adolescents with ASD, this stage of the research is informed by Social Cognitive Theory (SCT), an interpersonal-level theory that has been used in nutrition interventions for typically developing youth.

**Justification for the Use of Social Cognitive Theory**

SCT, which originated from Albert Bandura's Social Learning Theory (SLT) in the 1960s-1970s, involves using the interconnectedness of cognitive, behavioral, and environmental factors to explain goal-directed behaviors (Bandura, 1976). Cognitive factors, such as self-efficacy and outcome expectations, describe the role of the individual and their way of thinking in the process of behavior change. Behavioral factors, such as self-regulation and moral disengagement, describe the ways in which actions can enhance or compromise behavior change. Environmental factors, such as social support and normative beliefs, involve the ways in which physical and social environments impact behavior change. According to SCT, these three types of factors dynamically impact each other via reciprocal determinism.

Bandura's SLT is based on 1960s experiments that evidenced children's vicarious learning of aggressive behaviors through observation (Bandura et al., 1961). In contrast to prior

theories that saw behaviors as the result of conditioned reflexes (Pavlov, 1927) or positive or negative reinforcement (Skinner, 1953), SLT assumes that learning is social, i.e., that we learn from others, and that memories of observation guide later behaviors, especially if the "social role model" was of higher authority or if the event was emotionally charged. Another key assumption of SLT is that learning is an internal process, and behavior is mediated by cognitive processes through social modeling. Social Learning Theory was renamed to Social Cognitive Theory (Bandura, 1986) to highlight social and cognitive factors in explaining and predicting behavior.

The fully developed SCT model assumes dynamic interaction between person, behavior, and environment, i.e., reciprocal determinism. Underpinnings of SCT include five individual capabilities: symbolizing (using symbols to attribute meaning to experiences), forethought (regulating behavior by prior thoughts), vicarious (learning from observing others' behaviors), self-regulatory (setting internal standards for one's behavior), and self-reflective (analyzing one's experiences and thoughts) (Sharma, 2016). Current SCT constructs include cognitive factors, i.e., self-efficacy, collective efficacy, outcome expectations, and knowledge; environmental factors, i.e., observational learning, normative beliefs, social support, and barriers and opportunities; and behavioral factors, i.e., behavioral skills, intentions, and reinforcement and punishment (Glanz et al., 2015). Other constructs include reciprocal determinism and self-regulation/control, by which individuals engage in self-directed behavior through application of operant and cognitive principles (Glanz et al., 2015). Another variation of SCT includes environment, situation, and emotional coping responses (Glanz et al., 2008). The major constructs of SCT are defined in Table 2.

**Table 2. Major constructs of Social Cognitive Theory**

| | Construct | Definition | Source(s) |
|---|---|---|---|
| **Cognitive factors** | Self-efficacy | Confidence in ability to perform a behavior to achieve an outcome | Glanz et al., 2008; Glanz et al., 2015 |
| | Collective efficacy | Belief in group's ability to perform behaviors to achieve an outcome | Glanz et al., 2015 |
| | Outcome expectations | Judgments about the likely consequences of actions | Glanz et al., 2008; Glanz et al., 2015 |
| | Outcome expectancies | Values placed in a given outcome; incentives | Glanz et al., 2008 |
| | Knowledge | Understanding of health risks and benefits of health practices | Glanz et al., 2015 |
| **Environmental factors** | Observational learning | Learning new information and behaviors through observing others' behaviors and their consequences | Glanz et al., 2008; Glanz et al., 2015 |
| | Normative beliefs | Cultural norms and beliefs about behavior's social acceptability and perceived prevalence | Glanz et al., 2015 |
| | Social support | Perception of support a person receives from their social network | Glanz et al., 2015 |
| | Situation | Perception of the environment | Glanz et al., 2008 |
| | Barriers and opportunities | Attributes of the social or physical environment that make behaviors easier or more difficult to perform | Glanz et al., 2015 |
| | Environment | Factors physically external to the person | Glanz et al., 2008 |
| **Behavioral factors** | Behavioral skills/capabilities | Abilities needed to successfully perform a behavior | Glanz et al., 2008; Glanz et al., 2015 |
| | Intentions | Goals of adding or modifying proximal or distal behaviors | Glanz et al., 2015 |
| | Reinforcement and punishment | Provision or removal or rewards or punishments to increase or attenuate a behavior | Glanz et al., 2008; Glanz et al., 2015 |
| | Emotional coping responses | Strategies used to deal with emotional stimuli | Glanz et al., 2008 |
| **Additional constructs** | Reciprocal determinism | Dynamic interaction of person, behavior, and environment in which behavior is performed | Glanz et al., 2008; Glanz et al., 2015 |
| | Self-regulation/control | Personal regulation of goal-directed behavior | Glanz et al., 2008; Glanz et al., 2015 |



Strengths of SCT include the dynamic interaction between its constructs and the inclusion of cognitive, behavioral, and environmental factors. Using criteria proposed by Tzeng and

Jackson (1991), SCT ranks high on formalization, with well-defined constructs; fruitfulness, in that SCT has generated empirical research relevant to the current study; and scientific self-regulation, as its well-defined constructs ensure high replicability (Tzeng & Jackson, 1991). However, the theory lacks comprehensiveness (Tzeng & Jackson, 1991), in that community, organization, and policy factors beyond "barriers and opportunities" are missing. Although the constructs are well-defined, operationalization of SCT constructs varies based on the specific study, and the relationship between constructs and behavior change is undefined. Despite the limited scope of the theory, SCT is especially useful for guiding behavioral interventions (Glanz et al., 2015).

SCT has been used in a variety of nutrition education interventions for typically developing adolescents, including school-based interventions, such as Choice, Control, and Change (Contento et al., 2010) and Nutrition and Enjoyable Activity for Teen Girls (NEAT Girls) (Dewar et al., 2013), as well as community-based interventions, such as Snack Smart workshops conducted in a library setting (Freedman & Nickell, 2010), and online programs, such as Teen Choice: Food & Fitness (Cullen et al., 2013). Although a 2018 systematic review found weak evidence for the efficacy of SCT-based interventions on BMI (Bagherniya et al., 2018), several SCT-based interventions have been effective at improving dietary behaviors in adolescents (Contento et al., 2010; Cullen et al., 2013; Freedman & Nickell, 2010; Hoppu et al., 2010; Mihas et al., 2010).

Examples of other theories that have been used for interventions in typically developing youth include community engagement, a community-level theory, and Theory of Planned Behavior, an individual-level theory. Community engagement, a process of collaborative work with groups who may be connected to issues that impact their well-being by shared geographic

location or collective identity, originates from social justice and community change processes (Glanz et al., 2015). The term "community organization" comes from American social workers who coordinated services for immigrants in the 1800s (Garvin & Cox, 2001). Since the 1950s, community organization strategies have since been applied to social change objectives (Alinsky, 2010). Along with the history of community organization, community engagement is grounded in the World Health Organization (WHO) participation strategies, which highlight the public's role of "informed opinion and active cooperation" in health promotion (World Health Organization (WHO), 1958).

Strengths of community engagement include a focus on strengthening social networks, community empowerment, and a shared sense of ownership. However, there is a lack of well-defined constructs with clear pathways for behavior change, contributing to low formalization/coherence, parsimoniousness, and scientific self-regulation (Tzeng & Jackson, 1991). Nevertheless, community engagement has broad applicability (Tzeng & Jackson, 1991); in childhood obesity prevention, community engagement has commonly been applied in planning, implementation, and sustainability phases (Korn et al., 2018). As community engagement practice is still under development, its broad applicability and lack of formalization may be seen as limitations due to the lack of standardized guidelines for practice. However, the *Principles of Community Engagement* proposes a continuum from minimal community outreach to shared leadership and collaboration as a framework for community engagement research (McCloskey et al., 2011), and frameworks have been developed to guide the application of community engagement to public health interventions. For example, a conceptual framework by Brunton and colleagues operationalizes definitions, motivations, community participation, conditions, actions, and impact in the context of public health interventions (2017).

Specific typologies of community engagement also exist, such as Community-Based Participatory Research (CBPR) (Holkup et al., 2004; Israel et al., 1998). The conceptual logic model for CBPR involves the contexts and partnerships that shape an intervention and its outcomes (Wallerstein & Duran, 2010). CBPR has been used to engage adolescents to develop obesity prevention interventions (e.g., Livingood et al., 2017) and is particularly useful for interventions in vulnerable populations because of its emphasis on engaging community members as equal partners. Exploratory CBPR can be used to determine not only the needs of the community but also the connections that exist between individuals, services, and other entities, which can help to identify the constructs and pathways that are needed to meet the community's needs.

The Theory of Planned Behavior (TPB) focuses on individual motivational determinants of performing specific behaviors with the underlying assumption that intention is the best predictor of behavior. TPB is an extension of the Theory of Reasoned Action (TRA), which was developed by Fishbein in 1967 to better understand relationship between attitudes, intentions, and behaviors (Fishbein, 1967). Fishbein asserted that attitude toward a behavior (e.g., eating nutritious foods) was a better predictor of that behavior than attitude toward an object (e.g., obesity), in contrast to previous studies of relationships between attitudes and behavior, which found weak relationships between attitude (toward an object) and behavior (Glanz et al., 2015). The TRA includes attitudes and subjective norms as predictors of intention to perform a behavior, and perceived behavioral control, which originates from SCT's self-efficacy, was added as a third predictor in 1991 (Ajzen, 1991).

Similar to SCT, TPB is not comprehensive and does not explicitly consider community, organization, or policy factors. Whereas community engagement may lack clearly defined

constructs and individual-level factors, SCT and TPB have clear definitions for each of their constructs and lack community-level factors. SCT and TPB are also similar in their potential application to prospective intervention studies, even though their central tenets may differ, i.e., TPB focuses on individual intention to act and SCT focuses on learning as social. SCT and TPB differ in that TPB does not include social or environmental factors, such as barriers and opportunities or observational learning, since SCT assumptions of reciprocal determinism and learning as social are not integrated into TPB. The theories also differ in that intention is a proximal goal in SCT but follows attitudes, subjective norms, and perceived behavioral control in TPB.

TPB has been used to guide nutrition interventions that target dietary behaviors in adolescents, including school and social media campaign (Beaulieu & Godin, 2012), lecture and poster (Tsorbatzoudis, 2005), email (Kothe et al., 2012), and motivational (Gratton et al., 2007) interventions. According to a 2014 systematic review, nine of eleven TRA- or TPB-based intervention studies resulted in dietary behavior change, and TRA/TRB constructs were changed in ten studies (Hackman & Knowlden, 2014). However, while TPB constructs include individual-level measures of determinants of behavior change, these measures are broader and less comprehensive than SCT constructs. Additionally, TPB does not explicitly include environmental factors, such as social support and barriers and opportunities, that are included in SCT.

While there is a lack of theory-based interventions in adolescents with ASD, SCT is an appropriate approach for the target population in that personal, behavioral, and environmental factors all impact an adolescent's ability to make healthy food choices. Furthermore, adolescents with ASD may have cognitive and behavioral concerns (American Psychiatric Association,

2013) that can be captured by constructs of SCT. Existing interventions to improve diet in this population use behavior change approaches from fields other than public health, e.g., incorporating techniques from Applied Behavior Analysis (ABA) (Marshall et al., 2015) or Cognitive Behavioral Therapy (CBT) (Kuschner et al., 2017).

**Application of Social Cognitive Theory to the Current Study**

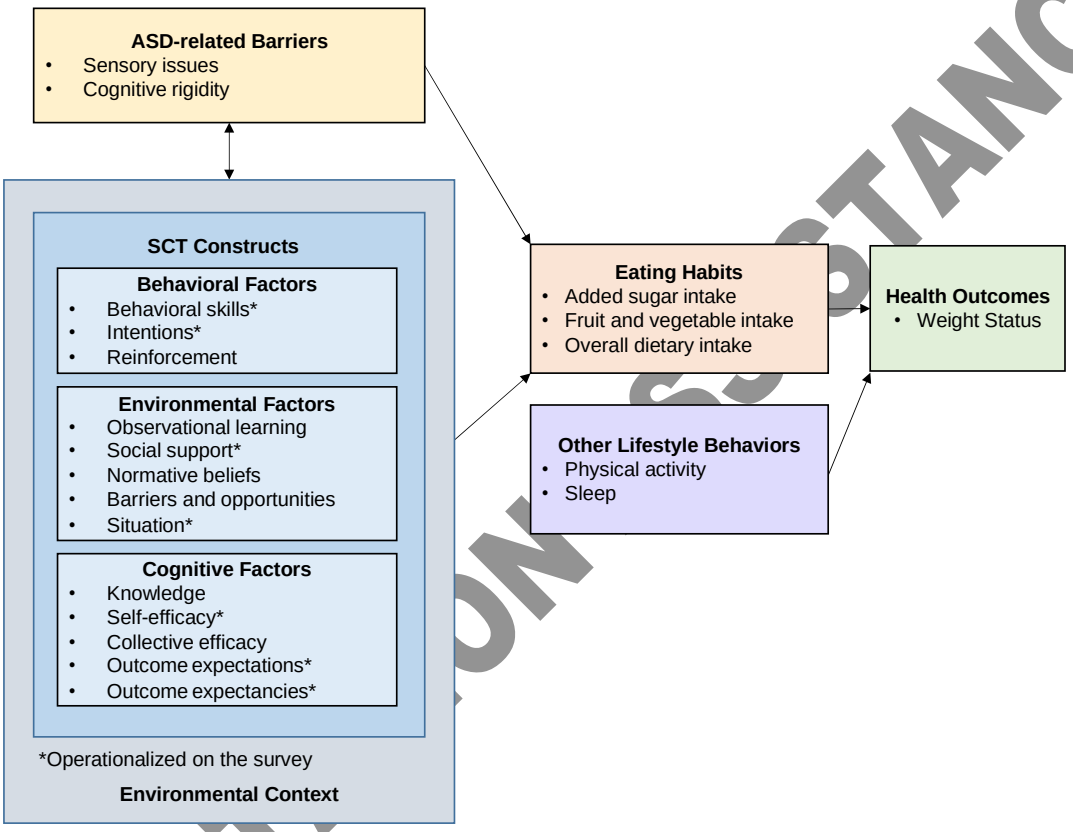


**Figure 1. Theoretical framework**

The conceptual framework for BALANCE is informed by SCT, which is commonly used in nutrition interventions in typically developing youth. As ecological perspectives of health behavior assert that multiple levels influence health behaviors and that multilevel interventions are most effective (Glanz et al., 2015), the framework also includes the broader environmental context to signify the broader community and environment. In addition to SCT (Glanz et al., 2008, 2015), the framework incorporates ASD-specific barriers, such as sensory differences

(Hazen et al., 2014; Kern et al., 2006; Leekam et al., 2007) and cognitive rigidity (Attlee et al., 2015; Gray et al., 2018; Polfuss et al., 2016), and other lifestyle behaviors that impact eating habits based on a review of the literature. The full theoretical framework is depicted in Figure 1.

**Intervention design.** To better understand needs for a nutrition intervention for adolescents with ASD, eleven adolescents and nine parents participated in formative focus groups and interviews (Buro et al., 2020). Thematic and comparative analyses were conducted to identify emergent themes, some of which aligned with SCT constructs. Observational learning was mentioned, as parents suggested that seeing peers make healthy choices would be an effective approach to encourage adolescents to make healthy choices, and adolescents mentioned that they would want to see someone eating healthy as part of a healthy eating program. Parents also discussed the importance of learning by experience, aligning with behavioral skills, as well as barriers, opportunities, and normative beliefs related to healthy eating. Knowledge and outcomes expectations regarding healthy eating were mentioned by both adolescents and parents.

***BALANCE curriculum.*** BALANCE consists of eight 45-minute lessons. Each lesson has activities that align with at least one SCT construct. For example, playing a matching game to match nutrients with their benefits in Lesson 3 is aligned with knowledge and outcome expectations. Guessing the sugar content of various beverages and practicing finding the sugar content on a nutrition label in Lesson 5 is aligned with observational learning and behavioral skills. Environmental factors are included in Lesson 2 (mealtime environment), Lesson 7 (restaurants and overall food environment), and Lesson 8 (home environment). The full list of lesson activities and their constructs is outlined in Table 3.

**Table 3: Application of Social Cognitive Theory constructs to lesson activities**

| Lesson 1: Exploring taste, flavor, and texture | | |
|---|---|---|
| **Minutes** | **Activities** | **Constructs** |
| 5 | Engage students in an interactive discussion of taste, flavor, and textures. | Knowledge, self-efficacy |
| 30 | Have a tasting session for foods with different tastes and textures. | Self-efficacy, observational learning, outcome expectations, normative beliefs |
| 10 | Work with students to plan to overcome barriers to exploring a new taste, flavor, or texture. | Outcome expectations, barriers and opportunities, intentions |
| **Lesson 2: Mealtimes and rules** | | |
| **Minutes** | **Activities** | **Constructs** |
| 10 | Discuss the benefits of having a regular mealtime schedule. | Knowledge, self-efficacy, outcome expectations |
| 10 | Discuss what the students' mealtime environments look like and why. | Self-efficacy, outcome expectations, barriers and opportunities |
| 25 | Make a healthy snack as a class and have each student set a goal for maintaining a regular mealtime schedule. | Behavioral skills, intentions, social support |
| **Lesson 3: Food groups and nutrients** | | |
| **Minutes** | **Activities** | **Construct** |
| 10 | Discuss the role of healthy eating in accomplishing personal goals. | Knowledge, outcome expectations, intentions |
| 15 | Play a matching game to match nutrients with their benefits. | Knowledge, outcome expectations |
| 10 | Create a sample meal using USDA MyPlate. | Knowledge, self-efficacy, observational learning |
| 10 | Discuss snacks and their food groups and benefits. | Knowledge, outcome expectations |
| **Lesson 4: Moderation** | | |
| **Minutes** | **Activities** | **Constructs** |
| 5 | Review the lessons so far. | Knowledge |
| 10 | Play a matching game with foods and level of processing. | Knowledge, self-efficacy |
| 10 | Review how to use the hand as a measurement guide. | Behavioral skills, observational learning |
| 15 | Practice writing down everything eaten for your last meal. | Self-efficacy, behavioral skills |
| 5 | Set a healthy eating goal. | Intentions |
| **Lesson 5: Beverages** | | |
| **Minutes** | **Activities** | **Construct** |
| 10 | Engage students in an interactive discussion on beverages. | Knowledge |

**Table 3 (Continued)**

| | | |
|---|---|---|
| 5 | Discuss how water and nutrient-dense beverages can meet the body's needs. | Knowledge, self-efficacy |
| 30 | Guess the sugar content of various beverages and practice finding the sugar content on a nutrition label. | Observational learning, behavioral skills |
| | **Lesson 6: Cooking** | |
| **Minutes** | **Activities** | **Constructs** |
| 10 | Discuss current practices for preparing food at home. | Self-efficacy, social support |
| 20 | Practice making a healthy snack. | Behavioral skills, observational learning, collective efficacy |
| 15 | Conduct a tasting session. | Observational learning, self-efficacy, intentions |
| | **Lesson 7: Well-being** | |
| **Minutes** | **Activities** | **Construct** |
| 10 | Identify healthy lifestyle components that can complement healthy eating practices. | Knowledge, outcome expectations |
| 10 | Describe challenges of the food environment. | Knowledge, normative beliefs |
| 10 | Describe ways to overcome challenges of the food environment. | Self-efficacy, outcome expectations, behavioral skills |
| 15 | Discuss mindful eating using herbs and spices as a prompt. | Observational learning, behavioral skills |
| | **Lesson 8: Sustaining healthy eating habits** | |
| **Minutes** | **Activities** | **Constructs** |
| 15 | Ask students to share their food with the group. | Observational learning, social support |
| 30 | Set a goal for sustaining healthy eating habits and award certificates of completion. | Intentions, reinforcement |

Application of SCT constructs to intervention activities was informed by the Child and Adolescent Trial for Cardiovascular Health (CATCH) intervention applications and strategies (Perry et al., 1997). Additionally, one activity was borrowed from the Laurie M. Tisch Center for Food, Education & Policy Food Day Curriculum (Koch & Contento, 2011).

An instructor's implementation manual and a participant lesson booklet were created for the virtual implementation of the BALANCE intervention. Sample lesson pages from the implementation manual and lesson booklet can be found in Appendices A and B, respectively.

***Parent component.*** Constructs of social support and barriers and opportunities were also targeted with a parent component, including webinars and email handouts. Parents were invited to attend three webinars (at baseline, after Lesson 4, and after Lesson 8) that summarize the lesson activities and provide relevant suggestions for encouraging healthy eating behaviors among their children. Webinar topics are listed in Table 4.

**Table 4: Application of Social Cognitive Theory constructs to parent webinars**

| **Topics for Webinar 1 (After Lesson 1)** | **Construct** |
|---|---|
| Introduction | N/A |
| Food preferences and barriers to trying new tastes and textures | Barriers and opportunities |
| Ways to encourage the child to try new tastes and textures | Social support |
| Ideas for nutrient-dense foods to have available in the home | Barriers and opportunities |
| Setting a mealtime routine/schedule with the child | Social support |
| **Topics for Webinar 2 (After Lesson 4)** | **Construct** |
| Food variety | Barriers and opportunities |
| Portion sizes for whole foods and processed foods | Social support |
| Shopping for whole foods on a budget | Barriers and opportunities |
| Making water and nutrient-dense beverages available at home | Barriers and opportunities |
| Encouraging the child to help prepare food | Social support |
| Healthy habits to complement healthy eating | Social support |
| **Topics for Webinar 3 (After Lesson 8)** | **Construct** |
| Lifelong benefits of healthy eating | Social support |
| Importance of family-style meals | Social support |
| Mindful eating | Social support |
| Restructuring the home environment | Barriers and opportunities |
| Role modeling for the child | Social support |
| Setting family goals | Social support |

Parents also received email handouts after each lesson that summarized the lesson's content and purpose. A sample handout is included in Appendix C. Future stages of the research will incorporate environmental changes, such as a manual for home, school, or community settings to adapt their environment to encourage healthy lifestyle behaviors for youth with ASD.

**Intervention implementation.** This study used a mixed-methods approach to allow for a comprehensive evaluation of the intervention's impact with exploration of additional factors that may impact the measures collected. Using previously evaluated instruments, quantitative data were collected on eating habits, social cognitive measures, physical activity, screen time, ASD behaviors, height, and weight. At the end of the intervention, focus groups were conducted with adolescents, and interviews were conducted with parents to examine acceptability, as well as other environmental factors that may impact eating behaviors in adolescents with ASD. The study aims are listed below.

***Aim 1: Assess feasibility of a virtual version of the BALANCE intervention based on fidelity checklists and engagement records and feasibility of virtually administering instruments to assess outcome measures, including psychosocial determinants of dietary intake, dietary intake, physical activity and sedentary behaviors, and anthropometric measures.*** Feasibility of the intervention was assessed via fidelity checklists and engagement records with measures on attendance, participation, homework, fidelity, and technical difficulties for each lesson. Checklists and records were completed based on review of video-recorded lessons. Feasibility of virtually administering the Block Kids 2004 Food Frequency Questionnaire (FFQ) and Physical Activity Screener (PAS) (NutritionQuest) (Cullen et al., 2008; Drahovzal et al., 2003) and a psychosocial survey (Dewar et al., 2012) was evaluated based on response rate, completion, and data quality. Feasibility of virtually assessing height and weight was evaluated based on response rate.

***Aim 2: Examine acceptability, perceived benefits, and unintended consequences of the intervention based on feedback from adolescents with ASD and their parents.*** Qualitative data collection included focus groups with adolescents and interviews with parents at post-

intervention. Semi-structured focus group and interviews were coded for Acceptability, Perceived benefits, and Unintended consequences, Eating habits, Other lifestyle behaviors, Food environment, Social Cognitive Theory, and ASD factors (e.g., sensory exposure and cognitive rigidity), as well as emergent codes. Qualitative data on eating habits and SCT constructs were used to triangulate findings from the FFQ and survey.

As it was expected that SCT constructs would not be able to explain all observed behavior change, qualitative research was also used to explore additional constructs to address in future stages of the intervention. Focus group and interview guides (Appendix D) were used to identify additional measures that may impact intervention outcomes, including physical activity, screen time, and food environments. Aim 2 findings on physical activity and screen time were also triangulated with quantitative data as measured by the Block Kids Physical Activity Screener (PAS) (NutritionQuest). Findings related to the environmental context will guide next steps for the intervention, which include scaling up to a multicomponent intervention. For example, future stages of the intervention may include a physical activity component.

***Aim 3: Determine preliminary efficacy of the intervention as measured by pre- and post-intervention mean differences in psychosocial determinants of dietary intake, dietary intake, and anthropometric measures.*** SCT constructs of self-efficacy, intentions, situation (perceived environment), behavioral strategies (behavioral skills), social support, outcome expectations, and outcome expectancies are operationalized in measures related to adolescent dietary behaviors that have been developed and evaluated by Dewar and colleagues (Dewar et al., 2012) reflecting the variation of SCT described in the 3rd edition of *Health Behavior and Health Education: Theory, Research, and Practice* (Glanz et al., 2008). The measures include 4-10 questions per construct for a total of 37 items. As the measures were developed in Australia,

some questions were modified for the current study to enhance clarity, e.g., “lite milk” was changed to “low-fat milk.”

Example items include: “I believe I have the knowledge and ability to choose/prepare healthy snacks” (self-efficacy), “In the next three months, do you intend to eat at least 3 servings of fruit each day?” (intentions), “At home there are healthy snacks available to eat” (barriers and opportunities), “In the past three months, rather than choose sugary drinks such as fruit juice or soft drink, did you choose water or sugar-free drinks such as diet soft drink?” (behavioral skills), “In the past three months how often did you prepare healthy snacks or meals with your parents/caretaker?” (social support), “Healthy eating can help me to feel better physically” (outcome expectations), and “How important is feeling better physically to you?” (outcome expectancies). Self-efficacy, barriers and opportunities, and outcome expectations are measured on a 6-point Likert scale from “Strongly disagree” to “Strongly agree.” Intentions are measured on a 4-point scale from “Not at all true of me” to “Very true of me,” and outcome expectancies are measured on a 4-point scale from “Not at all important” to “Extremely important.” Behavioral skills and social support are measured on a 4-point scale from “Never” to “Always.” The full survey can be found in Appendix D.

Behavioral outcomes of added sugar and fruit and vegetable intake were measured by the Block Kids 2004 FFQ (NutritionQuest) (Cullen et al., 2008), (sample in Appendix D), and BMI percentile, BMI z-score, and obesity prevalence were calculated based on pre- and post-intervention height and weight measurements. Height and weight were measured by parents as virtually instructed by research staff via Microsoft Teams based on the Centers of Disease Control (CDC) Guide to Measuring Children’s Height and Weight Accurately at Home (Centers of Disease Control [CDC], 2015). Wilcoxon signed-ranked tests were conducted to explore

whether the means in psychosocial determinants of dietary intake, dietary intake, and anthropometric measures differed from pre- to post- intervention.

**Planning and Evaluation**

To guide the measurement and assessment of BALANCE in a virtual setting, a comprehensive evaluation framework is necessary. Previous nutrition interventions in youth with ASD have not reported use of planning and evaluation frameworks but have reported implementation and fidelity measurements including adherence to session dose recommendations, environmental considerations, variety of foods offered (i.e., ≥30 foods total) (Marshall et al., 2015), and attendance (An et al., 2019). Studies conducted in other populations have used the RE-AIM (Reach Efficacy – Adoption Implementation Maintenance) framework and Consolidated Framework for Implementation Research (CFIR) to guide planning and evaluation of interventions.

**Justification for use of the RE-AIM framework.** The RE-AIM framework assumes that five dimensions – reach, efficacy or effectiveness, adoption, implementation, and maintenance – determine the impact of an intervention through interaction at multiple levels, e.g., individual and organizational levels (Glasgow et al., 1999). The impact score of an intervention is the product of all five dimensions, each scored 0 to 1 (0% to 100%). RE-AIM was created in response to limitations of previous evaluation methods, which oversimply reality, according to Glasgow and colleagues (Glasgow et al., 1999). The RE-AIM model builds upon Abrams and colleagues' definition of intervention impact as a function of its reach, i.e., percentage of population who receive the intervention, and efficacy (Abrams et al., 1996).

The five dimensions can be operationalized to fit the needs of a specific intervention, but general definitions are discussed by Glasgow and colleagues (Glasgow et al., 1999). Reach, an

individual-level measure, captures the proportion and representativeness of participants from the total target population. Efficacy, defined as positive minus negative outcomes of an intervention, highlights participant satisfaction, quality of life, and behavioral outcomes. Adoption refers to the proportion and representativeness of settings that adopt the intervention. Implementation involves the extent to which the intervention is delivered as intended in the real world, and effectiveness is defined as a product of an intervention's efficacy and implementation. Maintenance refers to sustained change at the community or organization level as the result of an intervention. Reach and efficacy are defined at the individual level, adoption and implementation are defined at the organization level, and maintenance is defined at both levels. However, the dimensions can exist and interact on more than one level depending on the intervention.

RE-AIM provides a structured framework to allow for comprehensive evaluation of interventions intended for large-scale dissemination. Whereas many program evaluations may focus on one or two dimensions (Glasgow et al., 1999), the inclusion of five dimensions in RE-AIM with the possibility of each dimension being measured at multiple levels can highlight more specific areas where improvements can be made. While RE-AIM is relatively comprehensive, the framework does not include constructs for characteristics of the intervention or individuals and groups involved in its implementation. Thus, RE-AIM has high formalization with well-defined constructs and high applicability in obesity interventions (Gaglio et al., 2013) but only moderate comprehensiveness (Tzeng & Jackson, 1991).

Glasgow and colleagues note further limitations, including the incorrect or arbitrary quantification of abstract concepts. The nature of relationships between dimensions is unclear, and the fact that their relationship is represented as multiplicative is likely a simplification. The model also assumes that all five dimensions are equally important, which may not be true.

Timeline guidelines for implementation (6 months to 1 year) and maintenance (2 or more years) are also arbitrary. These limitations provide potential opportunities for future research to refine and improve the model.

In contrast to RE-AIM, the Consolidated Framework for Implementation Research (CFIR) is a framework for approaching complex multi-level systems that consists of the following five domains: intervention characteristics, characteristics of the individuals involved, inner setting, outer setting, and the process of implementation (Damschroder et al., 2009). Each domain has several constructs: eight related to intervention, four for outer setting, twelve for inner seeing, five for individual characteristics, and eight for process. The framework was created for health services implementation research in response to interventions that are effective in research yet fail to translate into practice. CFIR is a meta-theoretical framework that combines constructs with overlapping definitions across published theories identified by Damschroder and colleagues (2009), building upon prior synthesis of implementation factors related to diffusion of innovation in organizations conducted by Greenhalgh and colleagues (2004). CFIR assumes that implementation is a social process linked to its context (Davidoff et al., 2008) and that its context is made up of active, interacting variables (Dopson & Fitzgerald, 2006).

An advantage of CFIR is its comprehensiveness; constructs are well-defined and formalized, making it relatively easy to operationalize for use. Due to the clearly defined constructs of CFIR, CFIR can be applied to intervention studies to ensure that the interventions can be understood, disseminated, and adapted in other settings. Similar to RE-AIM, CFIR does not address the relative importance of each domain or construct. However, prior research has reported whether they found constructs to be strongly, weakly, or not distinguishing between high and low implementation success (Varsi et al., 2015).

Whereas RE-AIM highlights five dimensions as measures of intervention impact, CFIR is much more descriptive, with a total of 37 constructs. CFIR operationalizes constructs from other theories in an effort to standardize terminology and encompass the broad range of constructs included in theories used to translate research into health practice, which may be unnecessarily complex and threaten the scientific principle of parsimony (Tzeng & Jackson, 1991). By contrast, RE-AIM highlights dimensions that are not necessarily addressed by existing theories but rather aim to quantify impact for use in intervention planning and evaluation.

Applications of CFIR to adolescent nutrition interventions include guiding the evaluation of school health programs (Leeman et al., 2018) and identifying factors for success in high school youth advocacy projects targeting healthy eating and active living (Bozsik et al., 2018). CFIR can be applied to interventions with clearly defined inner and outer settings, e.g., where constructs such as culture can be described. Related to the current study, CFIR highlights concepts that will be critical for potential implementation of BALANCE in established settings but may not be relevant for a feasibility study.

**Application of RE-AIM Model to the Current Study.** At this stage of the research, RE-AIM is a more appropriate planning and evaluation framework due to the small scale and undefined inner and outer setting. RE-AIM has previously been applied to formative evaluation and feasibility studies (e.g., Burke et al., 2015; Huye et al., 2014). The BALANCE intervention was implemented via Microsoft Teams the research team with a target sample size of 30 adolescent-parent dyads, who were recruited through the Center for Autism and Related Disabilities at the University of South Florida (CARD-USF). CFIR might have been more applicable if the intervention were to be implemented by staff members of community centers or schools with participants recruited from the centers or schools. RE-AIM has previously been

applied to community, school, and online interventions to improve healthy eating and physical activity (Hill et al., 2019; Jung et al., 2018; Lee et al., 2017; Lubans et al., 2016; Martinez et al., 2017). The RE-AIM Checklist for Inclusion of RE-AIM Issues by RE-AIM Dimension (RE-AIM, 2021) and an application of RE-AIM to evaluate a community-based, family focused healthy weight initiative by Jung and colleagues (2018) were used as models for operationalizing dimensions of the current study.

As the intervention was not integrated into an existing setting for the feasibility study, such as a school or an after-school program, reach was not defined at the setting level. Moreover, the use of online recruitment strategies, including shareable posts on the CARD-USF Facebook page, made it difficult to determine the true number of eligible participants who were exposed to the recruitment flyer. Thus, in addition to exclusion criteria and percent of individuals who participated in the intervention, reach was also evaluated through characteristics of participants compared to non-participants, as well as through qualitative methods to understand adolescents' and parents' motivation to participate in the intervention.

Effectiveness was measured by analyzing behavioral outcomes of added sugar intake and fruit and vegetable intake based on FFQ data, social cognitive measures based on survey data, and BMI z-score based on anthropometric measures, as well as through qualitative methods to better understand outcomes. Environmental factors that contribute to behavioral outcomes based on qualitative feedback were also considered when evaluating intervention effectiveness. Quantitative data were collected pre- and post-intervention, and focus groups and interviews were conducted at post-intervention.

The operationalization of adoption in this study is somewhat unusual since the research staff delivered the intervention online, rather than having staff at existing sites, such as schools

or community centers, deliver the intervention. Adoption was therefore evaluated by description of the virtual setting, as well as through qualitative methods to understand adolescents' and parents' feedback about the virtual setting.

Implementation was measured using fidelity checklists, engagement records, and field notes for each lesson. Lessons were video-recorded, and videos were analyzed to assess attendance, participation, homework completion, fidelity, and technical difficulties. The fidelity checklists included items specific to each lesson. Fidelity checklists and engagement records are depicted in Appendix D. Field notes further addressed the degree to which lesson objectives were met, as well as barriers and facilitators to implementation. Maintenance was not reported for this stage of the research.

As this is a feasibility study, thoughtful or exact calculations were not possible for each RE-AIM dimension. The purpose of applying the RE-AIM framework was to provide a multidimensional, descriptive evaluation to capture the strengths and weaknesses for future modification and efficacy study of the BALANCE intervention.

# CHAPTER III: METHODS

## Overview

The long-term goal of this research is to improve healthy eating habits in adolescents with ASD, ultimately reducing their risk of unhealthy weight gain. Youth with ASD have 41.1% greater risk of developing obesity, moderated by age (Kahathuduwa et al., 2019); exhibit an increased prevalence of unhealthy eating behaviors, such as consuming a narrow range of foods (Bandini et al., 2010; Marí-Bauset et al., 2014); and consume more energy-dense foods and fewer fruits and vegetables than typically developing youth (Sharp et al., 2013). Although eating habits represent a potential target area to reduce unhealthy weight gain in children and adolescents with ASD (Dhaliwal et al., 2019), existing nutrition interventions for children with ASD aim to improve feeding difficulties rather than healthy eating habits (e.g., Sharp et al., 2014; Tanner & Andreone, 2015). Nutrition interventions in adolescents with ASD have been conducted in heterogeneous samples, with other intellectual or developmental disabilities as inclusion criteria (e.g., Gephart & Loman, 2013; Ptomey et al., 2015), and thus may not address ASD-specific issues. Existing interventions in youth with ASD also do not address environmental factors, such as social support.

The purpose of this study was to examine the feasibility and acceptability of a virtual implementation of BALANCE (Bringing Adolescent Learners with Autism Nutrition and Culinary Education), a theory-driven nutrition intervention for adolescents with ASD. The aims of the study are: (1) assess feasibility of a virtual version of the BALANCE intervention based on fidelity checklists and engagement records and feasibility of virtually administering

instruments to assess outcome measures, including psychosocial determinants of dietary intake, dietary intake, physical activity and sedentary behaviors, and anthropometric measures, (2) examine acceptability, perceived benefits, and unintended consequences of the intervention based on feedback from adolescents with ASD and their parents, and (3) determine preliminary efficacy of the intervention as measured by pre- and post-intervention mean differences in psychosocial determinants of dietary intake, dietary intake, and anthropometric measures.

## Research Questions

Research questions for Aim 1:

1. Is the intervention feasible to implement virtually as measured by fidelity checklists and engagement records?
2. Is it feasible to virtually administer the Block Kids FFQ (Cullen et al., 2008) and Physical Activity Screener (Drahovzal et al., 2003) and a Social Cognitive Theory-based survey (Dewar et al., 2012) to adolescents with ASD as measured by response rate, completion, and data quality?

Research questions for Aim 2:

1. Is the virtual intervention acceptable to adolescents with ASD and their parents as reported during adolescent focus groups and parent interviews?
2. What are the benefits of the intervention according to adolescents with ASD and their parents as reported during adolescent focus groups and parent interviews?
3. Are there any unintended consequences of intervention participation according to adolescents with ASD and their parents as reported during adolescent focus groups and parent interviews?

Research question for Aim 3:

1. What is the preliminary efficacy of the intervention, as measured by pre- and post-intervention mean differences in psychosocial determinants of dietary intake, dietary intake, and anthropometric measures?

## Study Design

This feasibility study of a virtual implementation of BALANCE, a theory-based group nutrition intervention for adolescents with ASD, takes a convergent mixed-methods approach. Quantitative methods were used to measure feasibility of virtually implementing the intervention and virtually assessing psychosocial determinants of dietary intake, dietary intake, and anthropometric measures. Qualitative methods were used to examine acceptability of the virtual implementation, explore behavioral and environmental factors related to dietary intake, and collect feedback on perceived benefits and unintended consequences of the intervention. Based on findings of the school-based feasibility study and the age ranges of schools for youth with ASD, adolescents with ASD aged 12-21 years and their parents were recruited, with a target sample size of 30 adolescent-parent dyads.

To assess psychosocial determinants of dietary intake, a survey with measures developed and evaluated by Dewar and colleagues (2012) was virtually administered to BALANCE participants pre- and post-intervention. The Block Kids 2004 FFQ (Cullen et al., 2008) was virtually administered to participants pre- and post-intervention to measure dietary intake. One parent of each adolescent was recruited to fill out an online demographic questionnaire and Autism Behavior Inventory—Short Form (ABI-S) (Bangerter et al., 2017) and participate in an interview. At post-intervention, focus groups were conducted with adolescents and interviews

were conducted with parents via Microsoft Teams to get feedback on the intervention and ask about additional factors related to children's dietary intake.

**Setting**

The 8-week curriculum was implemented via Microsoft Teams. Microsoft Teams was selected as the virtual platform because it was officially supported by the University of South Florida. A virtual setting was appropriate given the risk of contracting or transmitting the SARS-CoV-2 virus in group gatherings during the timeframe for data collection (August-December 2020) (Centers for Disease Control [CDC], 2020).

Conducting the intervention in a virtual setting built on the school-based feasibility study by making the intervention accessible to adolescents who attend public or private schools, as well as those who are homeschooled. The virtual setting reduced participant burden by not requiring participants to travel to and from a physical location. The school pilot study was conducted in a school setting during normal class time, eliminating extra travel and time burden on adolescents and parents, yet adding burden for the school. The school administrators and teachers had to invest time scheduling the intervention and ultimately lost class time byreplacing their normal curriculum with BALANCE. A virtual setting did not impose on school time or scheduling and allowed participants to come from diverse backgrounds.

Participants were asked to have no distractions and no one else in the room unless assistance was required during BALANCE lessons. Parents chose whether they wanted to sit with their children during the lessons, stay nearby to listen without being on camera, or allow their children to participate entirely on their own.

**Sample**

The target population for the intervention was adolescents with ASD aged 12-21 years. Adolescent-parent dyads were recruited for the study with a target sample of 30 adolescent-parent dyads. The school-based feasibility study of BALANCE indicated that a school-based implementation of the intervention is feasible and acceptable for adolescents with ASD and that the instruments are appropriate when completed in-person for adolescents with ASD aged 15 and older. For the proposed study, parents were told that they could complete instruments or aid adolescents who required assistance, i.e., adolescents whose parents reported on the ABI-S (Bangerter et al., 2017) during the screening process that they cannot complete or that they need support to complete social communication tasks.

Participants were recruited through partnership with the Center for Autism and Related Disabilities at USF (CARD-USF). The recruitment flyer was emailed through a CARD-USF listserv, posted on CARD-USF Facebook page, and shared with other CARD centers throughout Florida. Support from CARD-USF was sought prior to submitting the study to the University of South Florida Institutional Review Board.

Eligible adolescents were clinically diagnosed with ASD and aged 12-21 years. Exclusion criteria included concurrent participation in another nutrition-related intervention, having below third grade reading level per parent report, having eating disorder or feeding disorder diagnosis per parent report, or being non-English speaking. Parents of adolescents participating in the intervention were eligible to participate in interviews. Exclusion criterion for parents was being non-English speaking.

Two cohorts participated in the 8-week intervention: the first cohort took place August-October 2020, and the second cohort took place September-November 2020. Based on

participants' reported availability during screening, groups were formed within each cohort. The first cohort was divided into two groups: Group 1 met on Thursdays at 5:00-5:45pm, and Group 2 met on Saturdays at 12:00-12:45pm. The second cohort was divided into four groups: Group 3 met on Wednesdays at 10:00-10:45am, Group 4 met on Wednesdays at 5:00-5:45pm, Group 5 met on Mondays at 5:00-5:45pm, and Group 6 met on Tuesdays at 6:30-7:15pm.

**Intervention**

BALANCE consisted of eight 45-minute lessons to be delivered via Microsoft Teams once per week for eight weeks. A lesson manual was created to guide the intervention, including aims, objectives, overview, preparation, procedure, and a teacher's note for each lesson. A lesson booklet was created for participants with an overview, preparation instructions, handouts, and take-home activity for each lesson. Samples from the lesson manual and lesson booklet are included in Appendix A. Lesson activities were aligned with SCT constructs, as summarized in Table 4. Each lesson included a tasting session or an optional snack. The food suggestions were flexible so that participants could use food that was readily available in the home. Lessons 1-7 had brief homework assignments to complete and return the following week. Every lesson had a parent handout that reviewed the lesson's purpose and activities. Parent handouts were sent via email after each lesson. If participants were unable to attend any of the lessons, a 15-minute make-up video was sent for their review. The make-up videos followed the same format as the lessons and were recorded in the same location. However, the make-up videos did not include any interaction from participants. For those parents unable to attend any of the three parent webinars, then webinar slides and notes were provided to parents via email.

Lesson topics were adapted from an early childhood nutrition intervention, Autism Eats, which was created by the research team (Van Arsdale et al., 2020), and further modified based

on pilot study participant feedback and discussion among the research team. Lesson 1 (Exploring Taste, Flavor, and Texture) includes tasting foods and planning to overcome barriers to trying new foods. Lesson 2 (Mealtimes and Rules) focuses on setting a regular mealtime schedule, identifying a comfortable mealtime environment, and practicing making a healthy snack. Lesson 3 (Food Groups and Nutrients) provides a matching game to match nutrients to their benefits, foods to nutrients that they contain, and foods to food groups. Lesson 4 (Moderation) has a matching game for levels of processed foods, asks students to practice portion sizes, and ends in setting a healthy eating goal. Lesson 5 (Beverages) includes a sugary drink demonstration and highlights the difference between water, nutrient-dense beverages (e.g., milk, orange juice), and sugar-sweetened beverages (e.g., sugary soda and sports drinks). Lesson 6 (Cooking) allows students to practice making guacamole. Lesson 7 (Well-being) focuses on tips for maintaining a healthy lifestyle (e.g., physical activity, sleep) and overcoming challenges of the food environment; the lesson ends with a mindful eating exercise. Lesson 8 (Sustaining Healthy Eating Habits) includes a virtual potluck meal and focuses on setting goals for sustaining healthy eating habits.

Lesson content was designed based on evidence-based strategies and findings from formative research. The curriculum incorporates data-driven strategies for adults with ASD, such as social engagement, emphasis on the individual, sensory/motor enhancement, emphasis on choice (Goldschmidt & Song, 2017), and visual supports (Kluth & Darmody-Latham, 2003). Primary formative research for the study, including focus groups of adolescents with ASD and interviews with parents of adolescents with ASD, also indicated that social engagement, visual components, and teen-led initiatives should be incorporated in the intervention. Ideas for theory-based activities came from previous research (Perry et al., 1997), and one activity (in Lesson 4)

was adapted from the Laurie M. Tisch Center for Food, Education & Policy Food Day Curriculum (Koch & Contento, 2011).

**Parent component.** Previous research has indicated that a parent component is important to change eating behaviors in youth with ASD, particularly young children (e.g., Johnson et al., 2015). Parent handouts and webinars were created as a low-burden parent component based on results from the school-based pilot study of BALANCE, which indicated that parents preferred webinar or website format, consistent with findings from our previous study conducted with parents of youth with ASD, which suggested that parents would prefer online articles, webinars, online sessions, or email newsletters to learn nutrition information for their children (Gray et al., 2020). Parents were asked to participate in webinars at baseline, after Lesson 4, and after Lesson 8. The webinars covered material from the lessons and showed parents how they can provide social support and opportunities for their children to maintain healthy eating habits. Webinars took place via Microsoft Teams. Webinar topics, outlined in Table 4, were informed by our early childhood nutrition education for early intervention providers and parents of children with ASD, Autism Eats, which was concurrently piloted, as well as findings from our previous study, which indicated that parents of children with ASD aged 2-17 years want to learn about effective feeding strategies, research evidence, and healthy eating (Gray et al., 2020). Additionally, handouts summarizing each lesson's content and purpose were emailed to parents after each lesson.

**Maximizing effectiveness.** The BALANCE curriculum was developed using a rapid-cycle evaluation approach to maximize the effectiveness of the intervention on its primary outcomes (Shrank, 2013). Focus groups were conducted with pilot study participants after Lesson 4 of the school-based feasibility study, and Lessons 5-8 were modified based on their feedback before implementing the second half of the intervention. Lessons 1-4 were

subsequently modified for future implementation of the intervention. As a rapid-cycle evaluation process should be driven by the school and the participants—not just the research team—verbal feedback was gathered from participants and teachers throughout the pilot study using open-ended questions and recorded as field notes to continually refine the intervention based on their feedback (Shrank, 2013). For the current study, the lead implementation coordinator delivered the curriculum according to the lesson manual that was modified based on stakeholder feedback. Further adaptations to accommodate the virtual setting were recorded on fidelity checklists and field notes.

**Key personnel.** Key personnel responsible for carrying out the intervention included an implementation coordinator, four research assistants, and a faculty advisor. The implementation coordinator oversaw all stages of research, implemented the intervention, and collected and analyzed data. Research assistants completed fidelity checklists and engagement records, assisted with height and weight measurements, and double coded 15% of the qualitative data. The faculty advisor (Heewon Gray, PhD, RDN) supervised the intervention implementation, including data collection, management, and analysis. The implementation coordinator and faculty advisor met weekly to discuss the study process. Additionally, the doctoral committee (Heewon Gray, PhD, RDN; Russell Kirby, PhD, MS, FACE; Jennifer Marshall, PhD, CPH; and Jamie Holloway, PT, DPT, PhD) provided content- and method-specific expertise.

## Instrumentation

**Survey on social cognitive measures.** There is a lack of instruments operationalizing SCT constructs related to dietary intake in adolescents. The measures developed and evaluated by Dewar and colleagues (2012) are readily available for use, appropriate for adolescents (mean age 13.7 years), and relatively brief at 37 items. For each scale (self-efficacy, intentions,

situation, social support, behavioral strategies, outcome expectations, and outcome expectancies), internal consistency was acceptable to good (α=0.65-0.79), and rank order repeatability was strong (ICC=0.81-0.89) according to the survey's initial evaluation study (Dewar et al., 2012). A survey for the current study was created based on the measures evaluated by Dewar and colleagues (2012) and pilot tested in 10 adolescents with ASD aged 8-19 years. The findings of the school-based feasibility study indicated that the survey is feasible for adolescents with high social communication skills and takes about 10-15 minutes to complete. For this study, participants completed the survey online via Qualtrics. Parents were asked to report via email whether their children required parent assistance to answer any questions. Scores were calculated for each question based on 4-6-point Likert scales, and mean scores were calculated for each scale on the survey.

**Block Kids Food Frequency Questionnaire (FFQ).** Few interventions have measured dietary outcomes in adolescents with ASD using self-report measures, e.g., photo-assisted food records with help of a parent (Ptomey et al., 2015) and checkboxes for fruit and vegetable intake and water intake (An et al., 2019). The Block Kids Food FFQ is a 77-item questionnaire that asks participants about consumption of various foods over the past week. The foods noted on the questionnaire are based on National Health and Nutrition Examination Survey (NHANES) 1999-2002 dietary recall data (Cullen et al., 2008). Pictures of portion sizes are included. The Block Kids FFQ was chosen because of its target age range (8-17 years), easy-to-read text, and low participant burden compared to other validated instruments. A sample portion of the Block Kids FFQ is depicted in Appendix D.

The school-based feasibility study of BALANCE indicated that the Block Kids FFQ developed for typically developing adolescents is feasible to complete for adolescents who have

high social communication skills and are aged 15 years and older. The Block Kids FFQ and 3-day food records were both piloted as part of the study. Only 50% of 3-day food records were returned with an 87% completion rate, and of those returned, 40% were completed by parents. The FFQ was completed by all participants; adolescents aged 15 years and older who were reported by teachers to have high social communication skills completed it independently, and adolescents reported by teachers to have limited social communication skills or who were under 11 years of age required assistance. Although data from 3-day food records may have higher validity than FFQs in general (Yang et al., 2010), the FFQ had a higher response rate, completion, and quality, in addition to lower participant burden, in the school-based pilot study.

For this study, participants were asked to complete the Block Kids FFQ through NutritionQuest's Data-on-Demand electronic system. A separate NutritionQuest user account was created for each participant's pre- and post-intervention FFQ. Participants were sent login information at the start of each data collection week and instructed to log in and complete the survey any time that week. In cases where participants had difficulty accessing the NutritionQuest survey, which required Adobe Flash Player to complete, participants were sent a Qualtrics link to a survey with the same questions, and the answers were manually entered into their NutritionQuest profile by the research team. FFQ data were translated into daily intakes of food and beverage items and nutrient and energy intake by NutritionQuest.

**Block Kids Physical Activity Screener (PAS).** The Block Kids PAS (NutritionQuest) was combined with the Block Kids FFQ by NutritionQuest so that participants could log in and complete the PAS after completing the FFQ without having to log in to a separate account or access another link. The PAS was administered to participants with the FFQ pre- and post-intervention to collect data on physical activity and screen time. The PAS asks about frequency

and duration of activities in the past 7 days, with 9 items on leisure and school activities, chores, and part-time jobs and one item on screen time (i.e., television, video games, and internet) per day. Self-reported physical activity is appropriate given the study objectives and sample size (Ainsworth et al., 2015). Additionally, previous research in children ages 9-10 years did not find significant differences between self-reported PAS measures and accelerometer-derived physical activity measures (Kattelmann et al., 2019). Physical activity was not measured in the school pilot study of BALANCE. The purpose of using the PAS for this study was to explore its feasibility in a sample of adolescents with ASD.

**Autism Behavior Inventory—Short Form (ABI-S).** One parent of each adolescent completed an electronic version of the ABI-S via Qualtrics pre- and post-intervention. The Autism Behavior Inventory (ABI) was developed as a parent-report scale to assess ASD symptoms and related behaviors of individuals age 3 years to adulthood with sensitivity to short-term changes (Bangerter et al., 2017). While many instruments aim to detect long-term patterns or changes, e.g., the Child Behavior Checklist asks about behaviors over the past 6 months (Achenbach, 1999), the ABI asks about behaviors over the past 7 days. The ABI covers five domains—social communication, restrictive repetitive behaviors, mood and anxiety, self-regulation, and challenging behavior—and thus can be used in place of several forms, such as the Social Responsiveness Scale (SRS-2), which focuses on social communication and restricted and repetitive behaviors (Constantino et al., 2003), and the Child and Adolescent Symptom Inventory (CASI)-Anxiety, which focuses on anxiety symptoms (Sukhodolsky et al., 2008). The version of the ABI-S available for download from Janssen Research & Development, LLC has 24 items.

As there is a lack of consensus on the validity of the distinction between high- and low-"functioning" ASD (Howlin, 2003; Macintosh & Dissanayake, 2004), the school pilot study

indicated differences in ability to complete study instruments based on teacher-reported level of social communication skills. The DSM-V defines three severity levels for ASD: Level 1 (requiring support), Level 2 (requiring substantial support), and Level 3 (requiring very substantial report) (American Psychiatric Association, 2013). However, adolescents with ASD and their parents may be unaware of their severity level depending on when they received their ASD diagnosis. Given the findings of the school-based pilot study, the ABI-S was used to dichotomize adolescents' social communication skills into high vs. low in this study.

**Ruler and scale.** Height and weight were measured by parents with a height rule and digital scale following procedures based on the Centers of Disease Control (CDC) Guide to Measuring Children's Height and Weight Accurately at Home (Centers of Disease Control [CDC], 2015). A scale and ruler were shipped to each participant, along with a lesson booklet. Adolescent-parent dyads were asked to sign up for a virtual height and weight appointment during the weeks of pre- and post-intervention data collection. Parents were asked to sign up for a 15-minute time slot based on their availability to meet for the height and weight appointment via Microsoft Teams. During appointments, parents were instructed by the implementation coordinator or a research assistant to complete height and weight measurements for their children, and the research staff recorded the values. Appointments lasted 5-15 minutes.

**Demographic questionnaire.** Adolescent participants answered questions on age, gender, height, weight, and race/ethnicity on the FFQ. One parent of each adolescent participant also completed a demographic questionnaire at screening, with questions on child's age, gender, race/ethnicity (Hispanic or Latino; American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or other Pacific Islander, White, other), school type (public, private, homeschool, other), co-occurring diagnoses (Sensory Processing Disorder, Attention-

Deficit/Hyperactive Disorder, Obsessive Compulsive Disorder, sleep disorder, other), food allergies or intolerances, hours of sleep the child gets per night, number of children in the household, total number of individuals in the household, household income (less than $20,000. $20,000 to $34,999, $35,000 to $49,999, $50,000 to $74,999, $75,000 to $99,999, over $100,000), food insecurity, as well as parent age, gender, race/ethnicity, marital status (married, widowed, living with partner but not married, divorced or separated, never married), and education level (less than high school, high school diploma or GED, some college, Associate's degree, bachelor's degree, graduate degree).

**Focus groups and interviews.** After the 8-week intervention, focus groups were conducted with adolescents and interviews were conducted with parents via Microsoft Teams. Semi-structured focus group and interview guides were developed based on Aim 2 to explore acceptability and perceived benefits and unintended consequences of the intervention. The focus group and interview guides can be found in Appendix D.

Each group of students was invited to participate in a focus group the week after their last lesson at the same day and time of their lessons. For example, Group 1 met on Thursdays at 5pm, so all participants from Group 1 were invited to participate in a focus group the week after Lesson 8 on Thursday at 5pm. Focus groups lasted 15-40 minutes. All parents in the intervention group were invited to participate in an interview, and interviews were scheduled based on parent availability. Interviews lasted 16-42 minutes.

**Fidelity checklists.** Fidelity was monitored by a checklist for each lesson. Each checklist was completed by one of three volunteer research assistants based on review of video recordings for each of the eight lessons. Each checklist included 9-11 lesson-specific components and checkboxes for completion and modification, as well as room for notes on reasons why the

component was incomplete or modified (e.g., not enough time, instructor skipped it, participants did not bring food) if a particular box was not checked. Components were marked as modified if they were completed in a way that was modified from the lesson manual (e.g., none of the students brought recipe ingredients, so the instructor completed a demonstration and discussion instead of leading the students to make the recipe). The fidelity checklists are depicted in Appendix D.

**Engagement records**. Engagement records were completed by research assistants based on review of the video recordings for each lesson. Engagement measures included attendance at the lesson start and end; minimum, maximum, and average minutes attended per student; verbal and nonverbal participation (Frequently, Occasionally, Rarely, Never); proportion of students who actively participated (All students, Most students, Few/some students, None); technical difficulties (Major difficulties, Minor difficulties, None); and number of students who completed the homework. Major technical difficulties were defined as those that interfered with the instructor's ability to complete the lesson (e.g., instructor is disconnected, or students are unable to see the instructor). Minor technical difficulties were defined as those that did not interfere with the instructor's ability to complete the lesson but may affect the lesson quality (e.g., student audio or video stops working). The engagement measures were the same for all eight lessons. Scales for engagement records were informed by a process evaluation study of a middle school nutrition curriculum intervention (Lee et al., 2013). Engagement records are depicted in Appendix D. Parent attendance was recorded for parent webinars.

**Field notes.** Field notes were used to document contextual information during and after BALANCE lessons based on a guide by Phillippi and Lauderdale; short notes were taken during each session, and comprehensive notes were taken immediately after each session (Phillippi &

Lauderdale, 2018). Field notes included contextual information about participants, virtual setting, and overall process, as well as reflexive description of the researcher's positionality, values, experiences, and relationships with the participants (Dodgson, 2019).

**Data Collection**

Feasibility data were collected for each lesson, and further data were collected at two time points: pre-intervention (baseline) and post-intervention (9 weeks from baseline). At both time points, surveys were administered to examine adolescents' psychosocial determinants of dietary intake (Dewar et al., 2012); the Block Kids 2004 FFQ (Cullen et al., 2008) was administered to measure dietary intake; the Block Kids PAS was administered to measure physical activity and screen time (Drahovzal et al., 2003); height and weight of adolescents was measured via ruler and scale; and the ABI-S (Bangerter et al., 2017) was administered to measure ASD symptoms and behaviors. Parents completed the ABI-S and a demographic questionnaire, as well as height and weight measurements, as guided by research staff via Microsoft Teams. Adolescents were asked to complete the survey, FFQ, and PAS. Parents were told that they could assist or complete surveys and questionnaires on behalf of the adolescents if assistance was required. At the end of the intervention, focus groups were conducted with adolescents, and interviews were conducted with parents to assess intervention acceptability and explore perceived benefits and unintended consequences of the intervention, as well as factors that may impact eating behaviors in adolescents with ASD that the intervention does not address. Participants were given one week to complete data collection at both time points (pre- and post-intervention).

**Behavioral Outcomes.** This study examined the feasibility of measuring behavioral outcomes of the BALANCE intervention. Evidence-informed dietary priorities to reduce the risk

of obesity, diabetes, and cardiovascular disease are numerous and include increasing foods from healthy food groups of fruit, vegetables, nuts, legumes, minimally processed whole grains, fish, and yogurt and decreasing foods rich in refined grains, starch, added sugars, sodium, and trans fat (Mozaffarian, 2016). As youth with ASD may consume more processed, energy-dense foods (Sharp et al., 2013) and sugar-sweetened beverages (SSBs) (Evans et al., 2012) and fewer fruits and vegetables than typically developing youth (Evans et al., 2012; Sharp et al., 2013; Siddiqi et al., 2019), added sugar intake – or intake of sugars that are added to foods or beverages when they are processed or prepared – and fruit and vegetable intake were selected as primary and secondary behavioral outcomes. These outcomes were also mentioned by adolescents and teachers during the school-based pilot study as areas to improve when it comes to adolescents' dietary intake.

Fruit and/or vegetable intake is a common outcome of nutrition interventions for youth with ASD that examine dietary outcomes beyond diet variety, or number of food items consumed (Ahearn, 2003; An et al., 2019; Cassey et al., 2016; Marshall et al., 2015), as well as nutrition interventions for typically developing adolescents (Birnbaum et al., 2002; Chamberland et al., 2017; Contento et al., 2010; Cullen et al., 2013; Freedman & Nickell, 2010; Haerens et al., 2007; Hoppu et al., 2010; Lytle et al., 2004; Ochoa-Avilés et al., 2017). Some of these interventions also measure SSB intake (e.g., Contento et al., 2010; Cullen et al., 2013; Haerens et al., 2007). A 2017 systematic review found 36 studies that aimed to reduce SSB consumption in adolescents aged 12-17 years (Vézina-Im et al., 2017). In addition to SSBs, number of snacks per day is associated with weight gain in adolescents aged 12-19 years in the US (Tripicchio et al., 2019). Added sugar intake was selected as an outcome of the current study to include SSBs and snacks that contain added sugar in one measure.

As the Block Kids FFQ and psychosocial survey both ask about fruit and vegetable and added sugar intake, these outcomes are particularly valid measures for the current study. The 37-item psychosocial survey includes 11 items that mention fruit and/or vegetables, two items that mention added sugar, and one item that mentions sugary drinks. The FFQ has numerous questions on fruit and vegetables and foods and beverages that contain added sugar.

The theoretical framework suggests that social cognitive factors based on SCT will predict the primary behavioral outcomes, and that those social cognitive factors will mediate the relationship between the intervention and the behavioral outcomes. A mediation analysis (Fritz & MacKinnon, 2007) was not conducted for this phase of the research, but the current study included analyses to investigate associations between the independent variable of the intervention (BALANCE) and dependent variables of psychosocial determinants of dietary intake (self-efficacy, intentions, situation, social support, behavioral strategies, and outcome expectations and expectancies), dietary intake (added sugar intake and fruit and vegetable intake), and anthropometric measures (BMI percentile, BMI z-score, and obesity prevalence).

## Data Analysis

### Quantitative Analysis

Univariate procedures including frequency distributions and descriptive statistics were performed for feasibility measures, including attendance, participation, homework completion, fidelity, and technical difficulties for the intervention lessons and response rate, completion, and quality for the Block Kids FFQ + PAS and psychosocial survey. Fidelity checklists were used to calculate percent fidelity for each lesson, and engagement records were used to calculate attendance, participation, homework completion, and technical difficulties. Response rate and

completion were calculated for the Block Kids FFQ + PAS and psychosocial survey. Procedures for assessing data quality are outlined in the following section.

Wilcoxon signed-ranked tests were conducted to determine whether added sugar intake, fruit and vegetable intake, total energy intake, self-efficacy, intentions, situation, social support, behavioral strategies, outcome expectations, outcome expectancies, BMI percentile, BMI z-score, ASD symptoms and behaviors, physical activity, and screen time differed from pre- to post- intervention. BMI z-scores were calculated from BMI percentiles following the LMS method for CDC growth charts (Flegal & Cole, 2013). McNemar's test was performed to compare obesity prevalence at baseline and post-intervention. Univariate procedures including frequency distributions and descriptive statistics were performed for all measured variables, including the variables for the Wilcoxon signed-ranked test analyses, as well as demographic characteristics. Dietary intake, physical activity, and screen time variables were quantitated by NutritionQuest. All quantitative analyses were performed in SPSS Statistics 24.0 (*IBM SPSS Statistics for Windows*, 2016).

**Quantitative data quality assurance.** Except for the demographic questionnaire, all quantitative instruments have previously been validated for typically developing adolescents. Prior to analysis, quantitative data were reviewed, and unreliable records were flagged through a three-stage process of screening (e.g., detecting outliers or inconsistencies), diagnosing (e.g., errors, missing data), and editing (i.e., correction, deletion, or leaving unchanged) (Broeck et al., 2005). Surveys were analyzed for response patterns, such as straightlining (choosing the same option for every item), diagonal lines, or a combination of both (Leiner, 2019). One FFQ was excluded for straightlining. All survey data were also screened for inconsistent or unrealistic answers, and none were detected. Missing data were handled with pairwise deletion. No missing

data analysis was performed because the amount of missing data was so low (4% of administered surveys and 0.4% of completed surveys) that it was assumed to be random rather than systematic. No data were missing from the completed FFQs due to the NutritionQuest forced-choice format. FFQ data were excluded if total energy intake was less than 500 kcal per day or greater than 5000 kcal per day based on previously defined cutoffs for outliers or implausible responses in children and adolescents (Rockett et al., 1997). Two FFQs were excluded for intake less than 500 kcal per day. None of the FFQs reflected intake greater than 5000 kcal per day.

**Qualitative Analysis**

Thematic analysis of data from focus groups, interviews, and field notes was conducted. For focus groups and interviews, a codebook with *a priori* codes based on the focus group and interview guides that aligned with the study research questions was created with the following parent codes: Acceptability, Perceived benefits, and Unintended consequences; as well as the following exploratory codes that reflected the theoretical framework for the study: Eating habits, Other lifestyle behaviors, Food environment, Social Cognitive Theory, and ASD factors (e.g., sensory exposure and cognitive rigidity). The definition of acceptability for this study was adapted from previous research (Sekhon et al., 2017), and includes the extent to which participants considered BALANCE to be appropriate based on their reported perceptions of and feelings about the intervention. Audio files from focus groups and interviews were transcribed verbatim by an external source. After an initial reading of the transcripts, emergent codes were added to the codebook. The full list of codes and sub-codes is depicted in Table 5.

**Table 5. Focus group and interview codes**

| Codes | Sub-codes |
|---|---|
| **Acceptability** | • Virtual format<br>• Group setting<br>• Autonomy/independence<br>• Sensory components<br>• Interaction<br>• Reinforcement (SCT)<br>• Parent component |
| **Perceived benefits** | • Diet changes<br>• Knowledge/awareness (SCT)<br>• Behavioral strategies (SCT)<br>• Self-efficacy (SCT)<br>• Outcome expectations (SCT)<br>• Outcome expectancies (SCT)<br>• Healthy weight<br>• Other lifestyle changes |
| **Unintended consequences** | • Anxiety/discomfort |
| **Context** | • Diet history<br>• Food environment<br>• Family support<br>• Changes due to COVID-19<br>• Motivation for participating |

SCT = aligns with construct from Social Cognitive Theory

Thematic analysis was conducted using MAXQDA qualitative analysis software (*MAXQDA, 2019*). A second coder separately coded 15% of the transcripts. Interrater reliability between the two coders was determined by percent agreement (90%) and Cohen's kappa calculations (0.9) (Cohen, 1960) in MAXQDA. Segmented data were extracted to matrices detailing *a priori* and emergent themes. Coded segments were analyzed to examine intervention acceptability, perceived benefits, and unintended consequences of the intervention, and to provide context for quantitative data regarding eating habits, lifestyle behaviors, and the food environment. Written field notes were typed and coded for emergent themes related to fidelity and engagement in MAXQDA.

**Qualitative data quality assurance.** The current study combines process- and output-oriented approaches to assess qualitative data quality. Process-oriented initiatives included keeping a field diary to reflect on position and assumptions and an audit trail to record methodological decisions, and output-oriented initiatives included data triangulation and member checking (Reynolds et al., 2011). One limitation of the current study is the researcher's vested interest in the topic and prior experiences related to the intervention and target population. Comprehensive field notes were taken to reflect upon reflexivity, responsibility, and ethical practices, and an audit trail helped to ensure transparency and a systematic approach. Focus group and interview questions on perceived benefits and unintended consequences of the intervention and factors related to eating behaviors not addressed in the intervention were triangulated with quantitative data, including FFQ + PAS, psychosocial survey, and ABI-S data. Member checking was conducted during focus groups and interviews by the researcher summarizing statements made by the participant(s) and then questioning the participant(s) to assess accuracy of the summary. Triangulation and member checking were conducted to increase rigor, credibility, and trustworthiness of the data.

## Planning and Evaluation

Guided by the RE-AIM framework, process evaluation included the fidelity and engagement checklists; Wilcoxon signed-ranked tests for primary outcomes; and qualitative description of all five RE-AIM dimensions. Table 6, adapted from the RE-AIM Checklist for Inclusion of RE-AIM Issues by RE-AIM Dimension (RE-AIM, 2021), summarizes how each RE-AIM dimension was applied to the study. The Maintenance dimension was not applicable to this stage of the research.

**Table 6. Application of RE-AIM**

| Dimension | Items |
|---|---|
| Reach | • Exclusion criteria<br>• Percent of adolescents who participated<br>• Characteristics of participants compared to non-participants<br>• Use of qualitative methods to understand adolescents' and parents' motivation to participate |
| Efficacy | • Wilcoxon signed rank tests for BMI z-score, fruit and vegetable intake, added sugar intake, and psychosocial determinants of dietary intake<br>• Use of qualitative methods to understand outcomes |
| Adoption (Setting Level) | • Description of virtual setting<br>• Use of qualitative methods to understand adolescents' and parents' feedback about virtual setting |
| Implementation | • Attendance<br>• Participation<br>• Homework completion<br>• Fidelity<br>• Technical difficulties<br>• Attrition<br>• Use of qualitative methods to understand implementation |
| Maintenance | N/A |



## Hypotheses

Hypotheses for Aim 1: (1) the virtual intervention will be feasible for adolescents with ASD as measured by fidelity checklists and engagement records and (2) the Block Kids FFQ + PAS, psychosocial survey, and height and weight measurements will be practical to administer virtually to adolescents with ASD, as indicated by high response rate, completion, and quality.

Hypothesis for Aim 2: the virtual intervention will be acceptable for adolescents with ASD and their parents as measured by focus groups with adolescents with ASD and interviews

with their parents. Aim 2 will also generate hypotheses regarding benefits and unintended consequences of the intervention.

Hypotheses for Aim 3: (1) Post-intervention means will be significantly greater than pre-intervention means for psychosocial determinants of dietary intake, including behavioral strategies, situation, social support, self-efficacy, outcome expectations, outcome expectancies, and intentions; (2) there will be a trend toward significance for dietary intake measures, including total energy intake, added sugar intake, total fruit intake, and total vegetable intake; and (3) there will be a trend toward significance for anthropometric measures, including BMI percentile, BMI z-score, and obesity prevalence.

**Protection of Human Subjects**

This project aimed to protect the human subjects involved. The study was approved by the University of South Florida Institutional Review Board (IRB) in July 2020. Informed consent/assent was obtained from all participants. The project presented minimal risk to human subjects. The BALANCE intervention is considered as a benign behavioral intervention that is brief, harmless, painless, not physically invasive, and unlikely to have a significant adverse lasting impact on the participants. All data were de-identified with numeric codes in a secured folder that only the research team could access. No personally identifying information was used in any report or dissemination product following this research. The study provided limited benefits to participants. Benefits included that participants may learn about healthy eating practices and socialize with peers in a virtual setting.

# CHAPTER IV: RESULTS

## Overview

This chapter presents the study findings, including the flow of participants through each stage of the study, participant characteristics, feasibility, acceptability, and outcome evaluation.

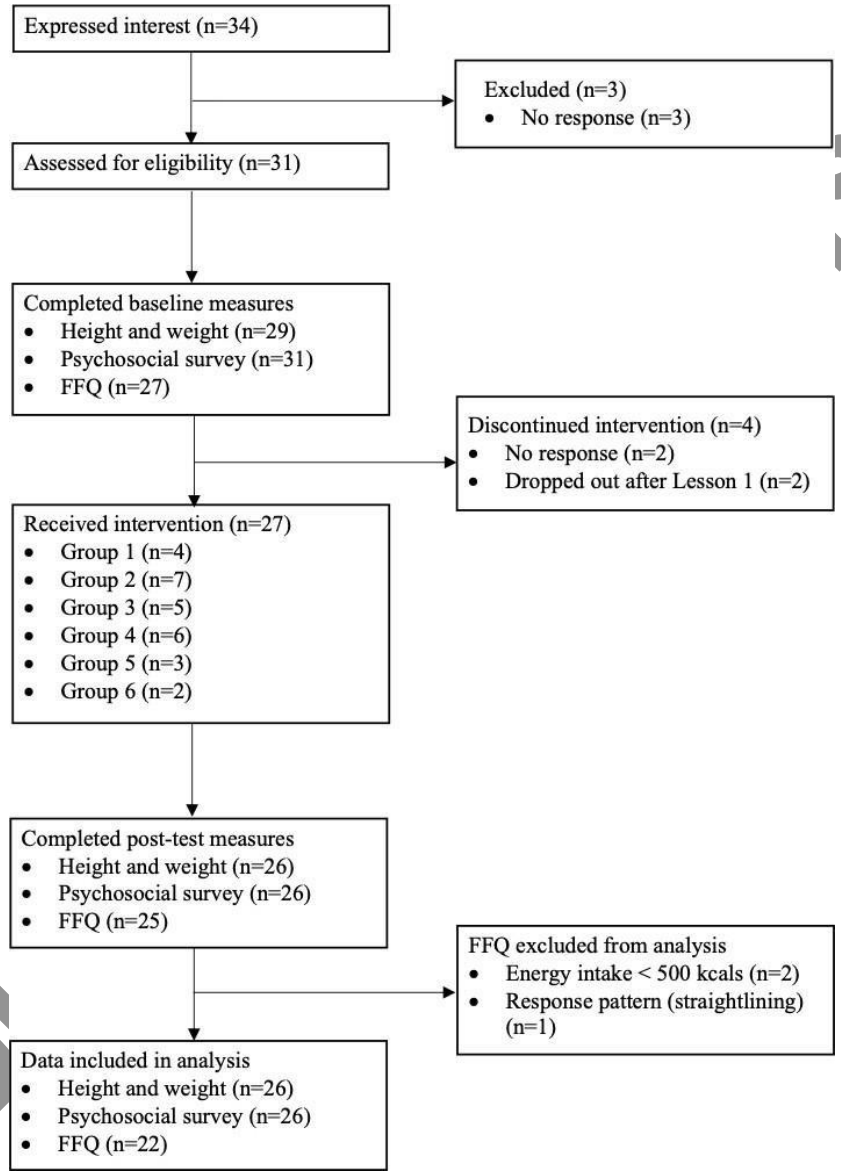


**Figure 2. Flowchart for study participation and data collection**

Figure 2 depicts the overall flow of the study. A total of 34 parents expressed interest in the study, and 31 completed the eligibility screening and informed consent. All participants who completed the eligibility screening for the study were deemed eligible. Two participants did not respond to follow up after eligibility screening and one or more baseline measures and were subsequently dropped from the study. Two adolescents dropped out of the intervention after Lesson 1. Both parents reported that their child's challenging behaviors during the lesson contributed to their decision to drop out. One of the parents also reported her work and school related stress as a contributing factor. Results are presented for the 27 adolescents who completed the 8-week intervention.

For qualitative data collection using focus group and interviews, 21 parents participated in an interview, and 12 adolescents participated in a focus group. One parent of each child was asked to participate in an interview. There were 20 mothers and one father who participated in an interview. One focus group was held for each group. Attendance per focus group was: 2 of 4, 5 of 7, 1 of 5, 1 of 6, 1 of 3, and 2 of 3.

**Reach**

Of those who expressed interest in participating, 91.2% responded and were assessed for eligibility. No participants were excluded after screening for eligibility. Compared to non-participants, participants had high social communication skills. Of the 27 adolescents who completed the 8-week intervention, 26 (96.3%) had high social communication skills. After all parent interviews and adolescent focus groups, participants were briefly asked about their motivation to participate in the intervention. Description of participants' motivation is described in the Acceptability section of the Results chapter.

## Participant Characteristics

### Child Characteristics

Table 7 shows demographic characteristics of the study participants as reported by parents. Of those who completed the intervention, 74.1% were male, 25.9% were female, and the average age was 14.9 years (range 12-20 years). The race/ethnicity breakdown of participants was 63% White, 14.8% Hispanic, 7.4% Black or African American, 3.7% Asian, and 11.1% Other. Participants who selected "Other" for the race/ethnicity option identified as multiracial (7% "Asian and White" and 4% "Latino and White")

Most participants were either homeschooled (44.4%) or attended public school (25.9%), with others attending private school (11.1%), or other school (14.8%). One participant had graduated from high school and was not attending any form of school at the time of study enrollment (3.7%). Description for "Other" school responses included virtual school (7.4%) and being in the process of transitioning from one type of school to another (7.4%; one transitioning from public to private and one transitioning from private virtual school to homeschool).

Participants had a range of co-occurring conditions. The most commonly reported diagnoses were Attention-Deficit/Hyperactive Disorder (77.8%) and Sensory Processing Disorder (40.7%). Over half of participants (55.6%) reported that they had one or more co-occurring diagnoses that were not listed on the questionnaire, including anxiety (22.2%), Auditory Processing Disorder (11.1%), and learning disabilities (11.1%), including dysgraphia, dyslexia, and non-verbal learning disability. Other responses mentioned by one participant each included: cerebral palsy, hydrocephalus, Fetal Alcohol Spectrum Disorder, Executive Function Disorder, epilepsy, periventricular leukomalacia, microcephaly, sleep apnea, progressive

infantile idiopathic scoliosis cardiac, premature ventricular contractions, migraines, thyroid issues, apraxia, and failure to thrive.

Parents were also asked about their children's food allergies or intolerances and average hours of sleep per night. Most participants (63.0%) did not report any food allergies or intolerances. Participants further specified food allergies and intolerances so that intervention lessons and discussions could be tailored to participants' dietary needs. Participants reported an average of 8.5 hours of sleep per night (ranged 6-12 hours).

**Family Characteristics**

There was a mean of two children in the household (ranged 1-5 children) and 4 total individuals in the household (ranged 2-7 individuals). Nearly half of participants (48.1%) came from households with reported income of $75,000 or greater. There were two participants (7.4%) with a reported household income of less than $20,000. Most participants (64.3%) reported "Strongly disagree" in response to the food insecurity question ("In the past month, did you ever feel like you didn't have enough money for food for your family?"). However, one participant (3.7%) responded "Strongly agree," and two participants (7.1%) responded "Somewhat agree."

All demographic questionnaire respondents were female and self-identified as participants' mothers on the ABI-S. The average age for mothers was 48.6 years (range 30-59 years). The majority were white (70.4%), married (74.1%), and had a bachelor's degree or higher (62.9%).

**Table 7. Demographic characteristics of study participants**

| Characteristic | Description n (%) |
|---|---|
| **Age**[a] | 14.9 (2.4) |
| **Gender** | |
| Male | 20 (74.1%) |
| Female | 7 (25.9%) |

**Table 7 (Continued)**

| | |
|---|---|
| Nonbinary | 0 (0%) |
| Decline to answer | 0 (0%) |
| **Race/ethnicity** | |
| Hispanic or Latino | 4 (14.8%) |
| American Indian or Alaska Native | 0 (0%) |
| Asian | 1 (3.7%) |
| Black or African American | 2 (7.4%) |
| Native Hawaiian or other Pacific Islander | 0 (0%) |
| White | 17 (63.0%) |
| Other | 3 (11.1%) |
| **School type** | |
| Public | 7 (25.9%) |
| Private | 3 (11.1%) |
| Homeschool | 12 (44.4%) |
| Other | 4 (14.8%) |
| Graduated | 1 (3.7%) |
| **Other diagnoses** | |
| Sensory Processing Disorder | 11 (40.7%) |
| Attention-Deficit/Hyperactive Disorder | 21 (77.8%) |
| Obsessive Compulsive Disorder | 2 (7.4%) |
| Sleep Disorder | 6 (22.2%) |
| Other[b] | 15 (55.6%) |
| **Food allergies or intolerances** | |
| Yes | 10 (37.0%) |
| No | 17 (63.0%) |
| **Hours of sleep per night[a]** | 8.5 (1.3) |
| **Number of children in household[a]** | 2.1 (1.2) |
| **Number of individuals in household[a]** | 4.0 (1.5) |
| **Household income** | |
| Less than $20,000 | 2 (7.4%) |
| $20,000 to $34,999 | 1 (3.7%) |
| $35,000 to $49,999 | 3 (11.1%) |
| $50,000 to $74,999 | 8 (29.6%) |
| $75,000 to $99,999 | 4 (14.8%) |
| Over $100,000 | 9 (33.3%) |
| **Food insecurity** | |
| Strongly disagree | 18 (64.3%) |
| Somewhat disagree | 4 (14.3%) |
| Neither agree nor disagree | 3 (10.7%) |
| Somewhat agree | 2 (7.1%) |
| Strongly agree | 1 (3.7%) |
| **Parent age[a]** | 48.6 (6.8) |
| **Parent gender** | |
| Male | 0 (0%) |

**Table 7 (Continued)**

| | |
|---|---|
| Female | 27 (100%) |
| Nonbinary | 0 (0%) |
| Decline to answer | 0 (0%) |
| **Parent race/ethnicity** | |
| Hispanic or Latino | 4 (14.8%) |
| American Indian or Alaska Native | 0 (0%) |
| Asian | 0 (0%) |
| Black or African American | 2 (7.4%) |
| Native Hawaiian or other Pacific Islander | 0 (0%) |
| White | 19 (70.4%) |
| Other | 1 (3.7%) |
| No response | 1 (3.7%) |
| **Parent marital status** | |
| Married | 20 (74.1%) |
| Widowed | 1 (3.7%) |
| Living with partner but not married | 0 (0%) |
| Divorced or separated | 6 (22.2%) |
| Never married | 0 (0%) |
| **Parent highest education completed** | |
| Less than high school | 0 (0%) |
| High school diploma or GED | 0 (0%) |
| Some college | 4 (14.8%) |
| Associate's degree | 5 (18.5%) |
| Bachelor's degree | 7 (25.9%) |
| Graduate degree | 10 (37.0%) |
| Other | 1 (3.7%) |

[a]Results represent mean and standard deviation; [b]Responses included: Anxiety, Auditory Processing Disorder, learning disabilities (dysgraphia, dyslexia, and non-verbal learning disability), cerebral palsy, hydrocephalus, Fetal Alcohol Spectrum Disorder, Executive Function Disorder, epilepsy, periventricular leukomalacia, microcephaly, sleep apnea, progressive infantile idiopathic scoliosis cardiac, premature ventricular contractions, migraines, thyroid issues, apraxia, and failure to thrive

**Symptoms of ASD**

Social communication scores were analyzed to classify participants as high vs. low social communication skills. All but one of the 26 students whose parents completed the baseline and post-intervention ABI-S had high social communication skills (mean > 2 out of 4). One student had a mean of 2 for social communication quality and frequency, indicating that they accomplish

social communication "with support" (quality) or "sometimes" (frequency). There were no differences in pre- and post-intervention mean scores for any of the ASD symptom domains based on the ABI-S. Pre- and post-intervention means for ASD symptoms based on the ABI-S are depicted in Table 8.

**Table 8. Pre- and post-intervention means for ASD symptoms**

| ASD Symptom (Values) | Baseline Mean (SD) n=26 | Post-intervention Mean (SD) n=26 | p-value |
|---|---|---|---|
| Language level[a] (1-5) | 5.0 (0.2) | 5.0 (0.0) | N/A |
| Social communication – Quality[b] (1-4) | 3.3 (0.5) | 3.2 (0.5) | 0.128 |
| Social communication – Frequency[c] (1-4) | 2.8 (0.6) | 2.8 (0.6) | 0.815 |
| Restrictive behaviors – Frequency[c] (1-4) | 2.2 (0.7) | 2.3 (0.6) | 0.189 |
| Mood & anxiety – Frequency[c] (1-4) | 2.5 (0.8) | 2.5 (0.6) | 0.806 |
| Self-regulation – Frequency[c] (1-4) | 2.2 (0.7) | 2.4 (0.8) | 0.069 |
| Challenging behavior – Frequency[c] (1-4) | 1.8 (0.6) | 1.8 (0.8) | 0.814 |

SD = standard deviation; [a]Response options: No language, Signs, Single words or 2–3-word utterances, Simple sentences, Full sentences; [b]Response options: Not at all, With support, With some reminders, Without help; [c]Response options: Never, Sometimes, Often, Very often

## Feasibility of Intervention Implementation

### Implementation Measures

Table 9 summarizes the results for implementation of the intervention, including attendance, participation, homework, fidelity, and technical difficulties. Major technical difficulties were defined as those that interfere with the instructor's ability to complete the lesson (e.g., instructor is disconnected, students are unable to see the instructor). Minor technical difficulties were defined as those that do not interfere with the instructor's ability to complete the lesson but may affect the lesson quality (e.g., student audio or video stops working).

There were six groups of adolescents who participated in the intervention. Group size ranged from two to seven participants. Four groups met on weekday afternoons or evenings (5:00pm or 6:30pm), one group met on weekday mornings (10:00am), and one group met on

weekend afternoons (12:00pm). Group meeting time and group size were determined based on the number of interested participants who were available at the same day and time of the week. Results for implementation are presented as group means.

All lessons took place on their scheduled day/time by the scheduled instructor. One lesson was scheduled on a different day of the week due to a holiday. Lessons were intentionally scheduled so that holidays with a food component (i.e., Halloween, Thanksgiving) would not interfere with lessons or data collection. Lessons lasted 30-45 minutes, with smaller groups (2-3 participants) consistently having shorter lessons.

Mean lesson attendance was 88% and ranged 50-100%. Participation was calculated from verbal participation (Never, Rarely, Occasionally, Frequently), nonverbal participation (Never, Rarely, Occasionally, Frequently), and proportion of students who actively participated (None, Few/Some, Most, All). Mean participation was 3.5 of 4 (4 being frequent verbal or nonverbal participation or all students actively participating) and ranged 2-4 (2 being rare verbal or nonverbal participation or few/some students actively participating. Mean homework completion was 51.9% and ranged 0-100%. Mean lesson fidelity was 98.9% with a range of 88.9-100%. Mean prevalence of technical difficulties was 0.4 of 2 (2 indicating major technical difficulties) with a range of 0-1, indicating no technical difficulties or minor difficulties for all lessons. Mean parent webinar attendance decreased from 72.7% in Webinar 1 to 36.6% in Webinar 3, with attendance ranging 20-100%.

**Table 9. Intervention implementation: Attendance, participation, homework, fidelity, and technical difficulties**

| Characteristic | Group Mean | Group Minimum | Group Maximum |
|---|---|---|---|
| **Lesson 1** | | | |
| Attendance | 90% | 80% | 100% |
| Participation[a] (1-4) | 3.7 | 2 | 4 |

**Table 9 (Continued)**

| | | | |
|---|---|---|---|
| Homework completion | 68.5% | 25% | 100% |
| Fidelity | 100% | 100% | 100% |
| Technical difficulties[b] (0-2) | 0.3 | 0 | 1 |
| **Lesson 2** | | | |
| Attendance | 88.7% | 57.1% | 100% |
| Participation[a] (1-4) | 3.6 | 2 | 4 |
| Homework completion | 48.4% | 20% | 100% |
| Fidelity | 100% | 100% | 100% |
| Technical difficulties[b] (0-2) | 0.3 | 0 | 1 |
| **Lesson 3** | | | |
| Attendance | 81.3% | 50% | 100% |
| Participation[a] (1-4) | 3.3 | 2 | 4 |
| Homework completion | 55.1% | 25% | 100% |
| Fidelity | 98.3% | 90% | 100% |
| Technical difficulties[b] (0-2) | 0.7 | 0 | 1 |
| **Lesson 4** | | | |
| Attendance | 88.3% | 66.7% | 100% |
| Participation[a] (1-4) | 3.4 | 3 | 4 |
| Homework completion | 54.4% | 0% | 100% |
| Fidelity | 100% | 100% | 100% |
| Technical difficulties[b] (0-2) | 0.3 | 0 | 1 |
| **Lesson 5** | | | |
| Attendance | 93.5% | 75% | 100% |
| Participation[a] (1-4) | 3.3 | 2 | 4 |
| Homework completion | 49.1% | 0% | 100% |
| Fidelity | 98.2% | 88.9% | 100% |
| Technical difficulties[b] (0-2) | 0.3 | 0 | 1 |
| **Lesson 6** | | | |
| Attendance | 83.7% | 50% | 100% |
| Participation[a] (1-4) | 3.7 | 3 | 4 |
| Homework completion | 42.4% | 33% | 100% |
| Fidelity | 94.5% | 88.9% | 100% |
| Technical difficulties[b] (0-2) | 0.3 | 0 | 1 |
| **Lesson 7** | | | |
| Attendance | 80.7% | 75% | 100% |
| Participation[a] (1-4) | 3.6 | 2 | 4 |
| Homework completion | 45.2% | 0% | 100% |
| Fidelity | 100% | 100% | 100% |
| Technical difficulties[b] (0-2) | 0.3 | 0 | 1 |
| **Lesson 8** | | | |
| Attendance | 97.6% | 85.7% | 100% |
| Participation[a] (1-4) | 3.5 | 3 | 4 |
| Homework completion | N/A | N/A | N/A |
| Fidelity | 100% | 100% | 100% |

**Table 9 (Continued)**

| | | | |
|---|---|---|---|
| Technical difficulties[b] (0-2) | 0.3 | 0 | 1 |
| **Total** | | | |
| Attendance | 88.0% | 50% | 100% |
| Participation[a] (1-4) | 3.5 | 2 | 4 |
| Homework completion | 51.9% | 0% | 100% |
| Fidelity | 98.9% | 88.9% | 100% |
| Technical difficulties[b] (0-2) | 0.4 | 0 | 1 |
| **Parent Webinars** | | | |
| Webinar 1 attendance | 72.7% | 50% | 90.9% |
| Webinar 2 attendance | 59.1% | 36.4% | 100% |
| Webinar 3 attendance | 36.6% | 20% | 50% |

[a]Participation consisted of: Verbal participation and Nonverbal participation (Response options: Never, Rarely, Occasionally, Frequently) and Proportion of students who actively participated (None, Few/Some, Most, All)
[b]0 = No technical difficulties, 1 = Minor technical difficulties, 2 = Major technical difficulties

Table 10 summarizes the mean, minimum, and maximum number of BALANCE lessons attended per student for each of the six groups. The total mean was 7.1 of 8 lessons. The minimum number of lessons attended was 4, and the maximum was 8.

**Table 10. BALANCE lessons attended per student**

| Group | Students per Group | Student Mean Lessons Attended | Student Minimum Lessons Attended | Student Maximum Lessons Attended |
|---|---|---|---|---|
| **Group 1** | 4 | 6.8 | 6 | 7 |
| **Group 2** | 7 | 6.9 | 4 | 8 |
| **Group 3** | 5 | 6.8 | 5 | 8 |
| **Group 4** | 6 | 7.4 | 6 | 8 |
| **Group 5** | 3 | 7 | 5 | 8 |
| **Group 6** | 2 | 7.5 | 7 | 8 |
| **Total** | N/A | 7.1 | 4 | 8 |

**Field Notes**

Emergent themes from field notes included Engagement, Modifications, Prompts, Distractions, and Technical difficulties.

**Engagement**. Many adolescents were actively engaged and attentive throughout the lessons. Most adolescents followed each lesson's preparation instructions and had food to share in front of the camera when instructed to do so. Occasionally, adolescents forgot to prepare, or, in Lesson 6, many adolescents did not have the ingredients for the guacamole-making activity. The virtual format allowed for visual cues between students and instructor, e.g., instructor holding up a paper with words written on it as a visual prompt or students showing eye contact and nodding in response to prompts. Nonverbal participation included holding thumbs up or down, nods, head shakes, eye contact, and holding up food or other items. For most groups, participants were most engaged in Lesson 6 and least engaged in Lesson 7.

**Modifications**. Modifications were made in four lessons overall. For three groups, there were no students who brought ingredients to make guacamole in Lesson 6, so the activity was modified to a demonstration by the instructor instead of a hands-on activity. For one group, the sharing snack activity in Lesson 3 was modified to the instructor showing and talking about snacks, as no participants brought a snack to share.

**Prompts**. Prompts successfully encouraged participation in all lessons. Sometimes adolescents only participated when supplied with visual or verbal prompts (e.g., instructor showing or reading the booklet) or when they were directly asked a question (e.g., "[Participant name], what do you think?"). When asked for their preference, participants said that they preferred cutout cards and images held up to the screen instead of viewing images through screen

sharing. Some adolescents did not like screen sharing. Two participants said, “We can’t see you anymore!” during screen sharing.

**Distractions**. Some adolescents were distracted by cell phones or other devices during lessons. Sometimes there was background noise that distracted participants until the participant with background noise was muted. Some participants had more verbal and nonverbal participation when there was no background noise or distraction.

**Technical Difficulties**. Technical difficulties included connection issues causing lag or a frozen screen and audio or video not working. Two participants regularly had difficulty logging into Microsoft Teams; both mentioned that they were using Chromebooks to participate in the lessons. Participants who mentioned that they used desktop computers, laptops, or tablets did not report regular difficulties logging in.

### Feasibility of Outcome Measures

The Block Kids PAS was included at the end of the FFQ. Of the 27 participants who completed the 8-week intervention, 27 (100%) completed the FFQ + PAS at baseline, and 25 (92.6%) completed the FFQ + PAS at post-intervention. Six participants (22.2%) at baseline and 9 participants (33.3%) at post-intervention were unable to access the NutritionQuest version of the survey due to technical difficulties (e.g., could not enable Adobe Flash). All but one of the participants who reported technical difficulties completed an alternate Qualtrics version of the questionnaire, and the responses were transferred into the NutritionQuest system by research staff. Completion rate was 100% for those who filled out the FFQ + PAS. Parents were told that they could assist their children in completing the FFQ + PAS if clarification or other assistance was needed. Eight parents reported that they helped their children clarify questions or recall food items consumed (e.g., “I helped him remember milk and bread”). Data quality was high for 88%

of the matched FFQs and 84% of the matched PASs. Two participants' responses were excluded from the FFQ analysis due to reported energy intake of less than 500 kcal per day. Another participant's responses were excluded due to a straightlining response pattern. For the 22 participants' responses that were included in the analysis, energy intake ranged 875-3121 kcal at baseline and 731-2469 kcal at post-intervention. An extreme outlier (reporting 4 hours of vigorous activity per day and 6 hours of moderate activity per day) was further excluded from the physical activity analysis.

Of those who completed the intervention, 27 (100%) completed the psychosocial survey at baseline, and 26 (96.3%) completed the survey at post-intervention. The completion rate at baseline was 98.9% (ranged 86%-100%), and the completion rate at post-intervention was 99.5% (ranged 97%-100%). Data quality was high for 100% of the psychosocial surveys. None of the surveys had inconsistencies or unrealistic responses.

Height and weight measures were taken for all 27 participants (100%) at baseline and 26 participants (96.3%) at post-intervention.

### Acceptability

Acceptability included the extent to which participants considered BALANCE to be appropriate, based on their reported perceptions of and feelings about the intervention (Sekhon et al., 2017). Based on participant responses, acceptability was further defined to include likes, dislikes, satisfaction, and suggestions for improvement regarding intervention components and activities. Parents and adolescents were asked for their feedback on the intervention content and format. Parents were also asked for feedback on the parent component, including parent handouts and webinars. Sub-codes regarding intervention acceptability included: Virtual format,

Group setting, Autonomy/independence, Sensory components, Interaction, Reinforcement, and Parent component.

**Virtual Format**

All participants reported that the intervention format was acceptable, although one had major technical issues and missed half of the lessons as a result. Adolescents and parents were mixed on whether they would prefer online or in-person format in general, but due to COVID-19, they all felt more comfortable with the virtual format.

Parents discussed how the virtual format was not only convenient but comfortable for their children, who were already used to virtual formats because they had been participating in virtual school and/or virtual therapy appointments. As one parent described:

> Well, he has been in online learning, and he understands how it works, how the interactions are expected. He's taken speech therapy via Zoom. But I think it will, of course, in ideal times without COVID, it will be perfect if there's some kind of meeting in person so they can interact with the other participants and probably they can have discussions around the foods. – Parent of a 15-year-old male

Another parent added that she wouldn't have driven her daughter somewhere for the lessons because driving there and back would added too much extra time:

> I have thought the virtual format is kind of nice. I feel like it enables people to be able to do it. I think that kids have gotten more used to it, and we're all more comfortable in it. And that you can do a 45-minute session. It's really only 45 minutes. It's not an hour and a half. Now, I wouldn't have driven some place for it. Does that make sense? So, offering it, I think is really nice, virtually. – Parent of a 15-year-old female

Parents also reported that the virtual format allowed them to have a sense of control over their children's behavior. One parent described how she liked the format because it allowed her son to interact with a group while she could stay nearby in case she needed to help him control his behavior:

> I really liked that a lot. That is very beneficial for [my son] and it is beneficial because I am very comfortable with whether his behavior needs to be controlled or not, I'm right

> here. And so, I don't have to worry about him being in a situation that I have to go fix later. So, it's just nice for him to have an opportunity to interact, certainly, it's probably not ideal from his point of view, but it gives me the kind of peace of mind to know he can interact and yet, I don't have to worry about whether he's doing anything that's inappropriate or misunderstood. So, yeah, it's really, really good for me. – Parent of a 16-year-old male

Some parents described how the virtual format was better for their children because they had social anxiety or social struggles that affect in-person socializing. For example, a parent of a 19-year-old female described, "For us, you know, I felt like it went really well. [She] struggles, some social, especially when she's in with crowds and more face-to-face. So, for us, virtually, it was a blessing."

Another parent mentioned that the virtual format was the reason she participated. She described how nutrition gets pushed aside when there are so many other appointments:

> Actually, I think I participated because it was online to be honest with you because the reality is that we have so many therapies and so many things going on that it's not that nutrition is not a priority but in the list of the things that you need to do, that you got to have a behavior analyst, you got to have the neurologist, the psychiatrist, the occupation therapist, the physical therapy. So, nutrition, well you know, you balance that, you say, "That can wait. That can wait." But the fact that we have this opportunity online, free, and with a kind person, it was unique. It was unique. And I think I loved the fact that it was online. – Parent of a 12-year-old male

Adolescents agreed that the virtual format was acceptable. An 18-year-old male said, "It's good since I'm used to it with my other group," and a 12-year-old female said, "I think it's better because I can see everyone."

Although the virtual format was perceived as appropriate, some parents mentioned that they would have preferred an in-person format if it weren't for the COVID-19 pandemic. As one parent described:

> I personally liked the online format. I prefer classroom format, but with what's happening right now, there was no way I'd let him go to a classroom, which he's actually homeschooled because of what's going on. He has a low immune system, so he became homeschooled this year. – Parent of a 13-year-old male

Dislikes regarding the virtual format included excessive screen time, mentioned by one parent, and technical barriers regarding Microsoft Teams, mentioned by one parent and one adolescent. One parent expressed concern with her son being "on overload" with screen time:

> I think the only negative I can think of is that he's on the computer all day. I think that you can't really... It's not normal times. If things were normal, he'd be going to school every day and then he'd have this when he got home. So, I think some days, it's just he's on overload and just over it, but he made it through quite few of them till the end. So, I can't think of anything negative. It was more in the moment, like he's just too tired or he had a difficult day and it's kind of not over yet and that kind of thing. But no, nothing negative. I think it was definitely worthwhile. – Parent of a 12-year-old male

A parent of a 19-year-old male described challenges logging into Microsoft Teams: "Unfortunately, the Microsoft Teams for us was a huge issue. Not your fault I know. It is horrible. It's not your fault. I tried everything and it just kicked me out of Microsoft Teams." During the intervention lessons, an 18-year-old male also mentioned that he had trouble logging into Microsoft Teams through his Chromebook.

**Group Setting**

Many parents mentioned how the group setting allowed their children to see other students' role modeling healthy behaviors, which aligns with the SCT construct of observational learning, or learning through observing others' behaviors and their consequences (Glanz et al., 2015). In particular, parents mentioned seeing other students try new foods and talk about healthy eating. One parent described beneficial "peer pressure" when asked what she thought about BALANCE:

> Like if I tell him to try something, you know, "It is mom telling me to try something," whereas if he is going to a class, and the other kids are all trying it. I think the peer pressure, but in a good way, I think it is helpful, which is one of the reasons I signed him up for the class, to see other kids are trying things, they try, you know, to eat different things. – Parent of a 14-year-old male

A parent of a 16-year-old male mentioned that it was good to for students to be able to see each other so they don't feel as isolated or unique: "I think they also like to see each other. Like, 'I don't like this,' or 'It doesn't feel like that,' and 'They have tried this.' They don't feel so isolated and unique sometimes."

Parents described how it was encouraging for their children to hear the other students speak up. A parent of a 16-year-old male said, "I thought it was good for [him] to hear all the other kids' opinions and hear them speaking up, so that it would encourage him to do that. I like that format."

One parent discussed how valuable the opportunity was for her son to see other participants his age who were talking about healthy eating:

> That's kind of what I'm looking for, just those opportunities to interact with other kids his same age. Since it was a teenage group, that was good. That was a great, great opportunity for him. I mean, I really cannot emphasize enough how valuable that was for him to see. To be blunt, those nice, pretty girls and talking like they were thinking about what they were doing, and so, he can see that, and if he doesn't get it right now, he's going to be able to figure out soon that that is good, positive behavior. – Parent of a 16-year-old male

Another parent described that seeing other students willing to learn about healthy eating made it feel more "important" or "legitimate":

> And I think with the class you did that it was nice that he was in there with other students. I feel like that they're all doing it together; it makes it more – I don't know what the word I'm looking for. I just think it's great that they were doing it together. And I think it makes it seem more important or legitimate, like when you're learning something all by yourself, and you don't think other people are learning it too. – Parent of a 12-year-old male

The same parent mentioned that the certificate of completion helped her son feel like he was part of a positive group activity:

> I think it was nice that you had that certificate to sign to pledge to make healthy choices. And back to the class, doing it together, like if he knows he's part of a group who's made

> a pledge to make the healthy choices, I think that's helpful, just knowing you're doing it together with these other people. – Parent of a 12-year-old male

There was one suggestion for improvement regarding the group setting. One parent mentioned how other students' behaviors were distracting for his daughter, so he recommended grouping students by similar age or ability:

> The only issue I had – which wasn't really with the program itself – it was hard to keep continuity going to keep her focused and interested with as many other people that were having more issues on the call… if there is any way to vet the group and put people into more appropriate capacity so to speak based upon your ability or your age level or whatever. – Parent of a 17-year-old female

**Autonomy/Independence**

Parents mentioned that the intervention fostered independence and provided opportunities for their children to develop autonomy related to healthy eating behaviors. This finding was especially prevalent in parents of adolescents aged 15 and older. Many parents mentioned that their children joined the online lessons without any prompting. One parent described:

> Yes, I do [think the format was acceptable] in the case of [my son]. I don't know with the other students. But I feel like [he] was really happy. At that time, I have classes scheduled at the same time, and I cannot be with him or prompting him to join all the time. He was in his own accord joining. I was fortunate enough with that type of thing. – Parent of a 16-year-old male

One parent described how the intervention format encouraged daughter to speak up and contribute to group discussions during BALANCE lessons:

> The program was really good. The material what they were learning was excellent. I like that she was involved in the activities. I also like that it helped her with speaking up in the group, with making herself heard and having a lot of good feedback and allowing good responses as I sat back and listened to what was going on. – Parent of a 17-year-old female

Many parents described how the guacamole-making activity in Lesson 6 was particularly helpful in fostering independence. As one parent described:

> I thought it was good. I liked how it was up to her. I liked how it's on the student somewhat because I know one of the things we're working on like some of the [special education school] kids here and all in groups that they are working on is becoming more independent and they had, actually she remind me, like, "Mom, we have to get this at store." But the fact that she did make the guacamole herself, I thought it was good. I think if they can get more independent for a lot of them, it's better for them. – Parent of a 16-year-old female

One parent mentioned that the parent handouts were helpful to keep her informed while her daughter was able to maintain independence and participate in the lessons on her own:

> I thought it was a great way to just keep me informed because I wasn't always here when [she] signed on for the class. So, I didn't always overhear, right. She was more independent. And again, that's why I liked the online version because it did allow her to have that bit of independence, which we are really striving for her adult life. Even though I did look at her book with her every week, and we did discuss the homework every week, it just reiterated and kept me in touch with what guys were doing. – Parent of a 19-year-old female

There were no dislikes regarding independence, but parents did express a desire for additional support to help their children develop independent skills. When asked for suggestions to improve the intervention, one parent said:

> Well, I guess I'm thinking in terms of we're at in [his] life. I don't know what if my personal goals with him match up with your particular goals for your program, but it would be great to have, because right now, I'm looking into, for example, him living independently, and one of the things that I worry about if he does live independently, and he's doing his own grocery shopping and that kind of thing. Is he going to go to the store buy all the junk food in the world, nothing nutritious, eat everything in one day, and then have nothing left to eat? Something that focuses on how to live life realistically, how to shop appropriately, how to make sure you're getting good nutrition, not just stuffing yourself with junk food, that kind of focus. – Parent of an 18-year-old male

Concerns for their children's independence were also described beyond what was included in the BALANCE curriculum. Parents mentioned specific goals that they had for their children to prepare meals on their own. For example:

> My goal is by making him to have at least two or three meals that he can prepare by himself completely without help. Now, he prepares himself some hotdogs and some other things. The pasta, we are in the working because he's scared. He loves the fish sticks, but

> then that will involve the oven. That's more of a prepare food. You just have to take them, pile them and put them in the oven. – Parent of a 16-year-old male

**Sensory Components**

Parents described sensory components as a positive aspect of the intervention, including visual supports and hands-on food exposure. Some parents alluded to their children's sensory differences with food and described how it was helpful to expose them to different foods. For example, one parent of a 16-year-old male mentioned that she liked "talking and then exposing the kids to those types of foods, touching the tomato, touching the broccoli, touching the beans and then – because there's a lot of sensory issues right there."

The guacamole-making activity in Lesson 6 was described by several adolescents and parents as a positive hands-on experience. One parent described:

> I will tell you, the avocado, guacamole, he was so proud of himself when he was done making it. And he loved that, so that was something I had not expected him to be that excited about once he, you know… I cut the tomato for him because he was a little scared to cut, but he did everything else himself, and he was he was very proud of that – Parent of a 14-year-old male

One parent mentioned her satisfaction regarding the guacamole-making activity even though her son did not try it himself. She described the sensory exposure as a positive experience:

> He didn't probably even know all of it now, his willingness to make the guacamole for me, even though he won't eat it, it leads us to working with something that's not in a texture or smell that he normally would like. And I think I learned some stuff too. – Parent of a 12-year-old male

Adolescents and parents also reported that they liked the images and colors in the lesson booklet that was mailed for their children to use throughout the intervention. As one parent of a 12-year-old male described, "I love the book. It's colorful. It's easy to read. It's perfect. The descriptions are good." A parent of a 16-year-old male mentioned that she particularly liked the

images for Lesson 3: “Well, the thing that I did particularly like was the graphic images for the nutrients, I think that was absolutely ideal.” A 13-year-old male said, “the booklet made it interacting.”

One parent reported that she will continue to use the booklet to complement other visuals that she has to promote independence for her child:

> The visuals were huge for him to be able to see it in that format. Some of that stuff I will ultimately end up kind of shaping and adding it to the other visuals that I have for him to promote independence, such as packing his own lunch, making sure we have one thing out of every certain group, etc. – Parent of a 14-year-old male

Parents mentioned additional visual supports as a suggestion for improvement. One parent described how the visual supports could have been improved by including cards in addition to the booklet:

> The only thing that would have been better would have been, and I thought about doing it, taking the pages out and cutting them up into little cards. That would be a very nice, you know, tactile, visual reinforcer for him. I especially liked the way you had the molecules for the different nutrients so he could see because he was doing that same thing in biology where he’s looking at that molecular structure and see the complexity of some, like the proteins compared to some of the others, obviously, like water and stuff would be simpler. That was kind of a nice visual for him. – Parent of a 16-year-old male

Another parent described how a poster of the food groups discussed during BALANCE lessons would be helpful for both adolescents and parents:

> I really would’ve liked like some kind of poster or some type of – where maybe I could put in my kitchen and write some of the snacks from the cabinet that fall into the different categories to kind of help him make a better choice. You know what I’m saying? Like, “Okay, you’re supposed to have four of these today. You’re supposed to have five of these today. Why don’t you go to the poster, find a couple of the things that are on there, and pick a couple of things that you might want,” to kind of help him kind of put the food into the particular groups, like, “Oh, well I had my bread and my-this, I need a couple more vegetables today.” Something where maybe even that day he could be like a dry eraser where you can just like write what he’s had already so he can kind of figure it out for himself. Just a visual. He needs visuals. – Parent of a 13-year-old male

One parent, who is a behavior analyst, discussed how the parent component could be improved with more visuals on the handouts that represent real-life implementation examples:

> Again, no, I love it, I guess from behavior analyst in me again, we were on the same page on so many different things. But that implementation may be different ways that parents implement the information that you're providing. One of those, I think one of the things said something about food or grouping food to make it easy access… I think one of the – your handouts talked about that, but for example for us, we have bins in our pantry that say "fruit," that say "desserts," that say "protein source," individually labeled, so when he's packing his lunch for the day, he can go straight to be like, "Okay, anything in this basket is protein, which is great for an afternoon snack and healthy." Maybe just some real-life examples for different resources, even visuals that I can put in the refrigerator to help generalize what you guys were bringing to the table. – Parent of a 14-year-old male

**Interaction**

Adolescents and parents mentioned that the intervention offered opportunities for interaction and socialization. Some reported that they were motivated to participate because they hoped for such opportunities, especially as their children had been feeling more isolated due social distancing in response to the COVID-19 pandemic. One parent described her satisfaction with the opportunity for her son to engage in a positive social activity:

> I also like the fact that it is kind of like a social thing as well that he could be on with other kids who are like him. I like that it was an activity other than playing video games that he can participate in. I'm always looking for anything positive that he could participate in that is not a video game. – Parent of an 18-year-old male

Another parent described how the chance to socialize with other students was an unexpected positive of participating:

> I like really like it to be honest. I was really happy because he even took it like a time for socializing with other children. That was something that I was not anticipating and was totally unexpected and really beneficial for them. – Parent of a 16-year-old male

As one parent mentioned, the need to interact with other students is especially important during the COVID-19 pandemic:

> I like the idea that each week the lesson is growing and having them explore more things. I think that is great. I like the interactions with other students, especially now with

> COVID. I do think he liked it. He has a hard time remembering appointments, and he seemed to remember this one, so he must have liked it. – Parent of a 14-year-old male

Parents also described that they liked how the intervention offered engaging interactions between participants and the instructor:

> I was very impressed by the material. I was very impressed by the format and the time limit was really great—just enough time to keep them focused and keep their attention. I felt like you handled all of the participants very well, that the times that I was there, you were very respectful. You would listen when some of the kids would mention some stuff. You were very patient with everything, the times that I overheard the classes. So, again, I felt like it was a great program. I'm really glad we participated in it. I really appreciate that. – Parent of a 19-year-old female

A parent of a 16-year-old male described, "You did a wonderful job. I was so impressed. After him being in therapy for so many years and listening to therapists, you were like this breath of fresh air that he responded to and it was nice change."

Although many parents listed interaction and socialization when they described their satisfaction with BALANCE, two parents reported that there was not enough of a social aspect to the program. One parent, whose son was part of a three-student group with diverse ages, described:

> I thought it gave a well-rounded nutrition education. I was hoping that it would also be more of a social opportunity for him to meet some other kids. So, that part didn't really go as planned. It was engaging. It held his interest most days. – Parent of a 12-year-old male

One adolescent mentioned that he also would have liked more interaction. He described:

> One thing that I was hoping to get in here was to interact, and, which I sort of kind of got it. That's sort of what we did. I'd rather do that than get COVID, for me, anyway. I just don't feel like I, we did enough of it, in my opinion. – 14-year-old male

Another parent mentioned that an in-person format would allow for more interaction:

> I think classes like this are great. I do wish, like I said, it was in-person, so he would have that interaction, but the more he learns about that because he does talk about it. I mean, he talks about, you know, "Is my chicken healthy, Mom?" You know, those kinds of things, so he does want to eat healthy, it is just… I think if someone else is telling him to

> eat something, it comes off better to him than if it is just mom telling him. "Oh, it's Mom doing it again," you know. – Parent of a 16-year-old male

**Reinforcement**

Parents discussed reinforcement, a SCT construct referring to provision or removal or rewards or punishments to increase or attenuate a behavior (Glanz et al., 2015), with regard to homework and parent handouts/webinars reinforcing what was taught during the intervention lessons, as well as the lessons reinforcing knowledge that students already had prior to participating.

Parents described how the homework for each lesson kept students thinking about the topics discussed and allowed them to apply their knowledge to everyday life. As one parent of a 14-year-old male described, "I think it made them more invested and committed. And for us anyway, it allowed him to think independently and applied some of the knowledge in refreshers that he had into everyday life."

Another parent had similar feedback:

> It was another way to just keep those thoughts present in her mind. Like, "Oh, I have homework to do, so I got to think about what kind of food I ate," or, "Was it healthy food?" Or the day you prepared a guacamole. Personally, that's something we make a lot in our household. She's never made it. But I just thought that the homework was a good way to just keep it more present in their mind and keep them connected. – Parent of a 19-year-old female

One parent described how the parent handouts allowed her to help her son complete the homework:

> Because he would ask me like, he'd be reading the homework four days later and not remembering what was discussed and not wanting to go back and reread the book. I already knew what he had done because I've looked at the parent handout, so I was able to kind of, "Hey, but this is what they're talking about," or, "This is what they mean when they say that" or – so it was helpful… This place is a little bit of a mad house. So, a lot of times, I forget just- but I thought they were very helpful. I thought they were very informative, and it was nice to like be able to understand what he was doing and not having to like go back and research it myself or try to figure out what in the world he's

whining about. I knew exactly what was coming and exactly what he was doing. – Parent of a 13-year-old male

Another parent mentioned how the parent handouts helped her stay updated on what was discussed during BALANCE lessons:

> I just didn't know what exactly you guys were learning in class or what the kids were learning in the classes. I think that was beneficial for us to know. I could kind of talk to her about it as well because I didn't sit next to her for – I have a 2-year-old, I got an 8-year-old, I'm all over the place, so it was just kind of like reinforcing what she did in the program itself. I think it was beneficial. – Parent of a 12-year-old female

Two parents mentioned that they had already tried teaching their children about some of the topics covered during the lessons, so the lessons reinforced their existing knowledge. One parent, who is a behavior analyst, described:

> Definitely a lot of great amazing information. I think it was good for him to hear it from someone other than me. A lot of the stuff that you mentioned in the program is stuff that we have been doing just for the past several years slowly building upon, so I definitely think it was good. – Parent of a 14-year-old male

Another parent discussed how BALANCE gave her children the opportunity to learn about healthy eating from someone else:

> I'm just mainly happy because through this program, they learn about healthy eating from someone else other than me. So that was a very positive thing for them to hear, and reading the booklet from someone else because I have been telling them for years, and that was a positive thing for them. – Parent of a 17-year-old male and a 14-year-old female

Suggestions for improvement related to reinforcement included suggestions for visual reinforcers, such as cards and posters, as described in the Sensory Components section. Additionally, while the homework was described as reinforcing by most parents, two parents of 12-year-olds mentioned that homework was a burden for parents. One described the parent burden of homework:

> You need to realize that it is not homework for the kids, that it is homework for mom. Immediately when the class shuts down, they forget everything. They can be amazing in

> their memory, but they don't remember that. If it's an option, I will design activities that they can do as part of the group. You can continue during the week, or I really like the fact that he needed to cook and help cooking because he did that and he was able and happy to do it. – Parent of a 12-year-old male

**Parent Component**

While most parents had positive feedback about the parent handouts, feedback about the parent webinars was mixed. Parents described how the weekly email handouts allowed them to stay updated on what was covered in the lessons, as illustrated by the following quotes:

> I like getting them because I am definitely… I am a helicopter mom I guess, so I like to see what he has talked about because I did give the privacy, you know, that you asked for them to be on their own and in the room alone unless they needed assistance, so that they would be more independent. I did do that, so I do like to follow-up and knowing what happened and how it went. – Parent of a 14-year-old male

> I thought they were good. I read them. I think it was nice to have to know what was going on because I'm not sitting next to him listening to hear what's going on, and then we could follow up with that stuff, so no, I thought that was a nice component. – Parent of a 15-year-old male

> I did look at them all, and I thought they were beneficial because since [he] was taking the iPad out of the room, I wasn't participating in the class, except for the one time when I helped with food. But I think those were good because it gave us an update on what was covered and everything. – Parent of a 12-year-old male

Some parents mentioned that they were too busy for the parent webinars. Webinar attendance ranged 20-100%, and attendance decreased for nearly all groups from the first to last webinar. A parent who attended the weekly BALANCE lessons with her son mentioned that she was too busy for the webinars or the handouts:

> I can't say I spent a lot of time on them because I'm kind of on overload too by the end of the day. I skimmed them, but yeah. I don't know that I really had the mindset to really focus on them once the weekly class was over. I don't know if I made it to any of the parent webinars. Again, it's just because after a whole day of doing school at home, and then by 5:30 it's like, I've got to start dinner. I also have a high school aged daughter at home. By the end of the day, more than once a week, I just couldn't make it happen. – Parent of a 12-year-old male

Two parents suggested that parents should be asked to join on the virtual platform for 10-15 minutes after each intervention lesson to review what was covered and what is needed for the following week, as illustrated by the following quotes:

> Maybe you have the group with the kids for 45 minutes and then you have the parents for the last 15 minutes where you say, "This is what we talked about. This is what I want you guys to do for the next week. Why don't you email it to me Monday night?" or something like that. – Parent of a 20-year-old male

> I mean, maybe the good idea is, have the parents come in the last 10 minutes? Maybe do a recap with them so they are involved because otherwise, they just leave them in the room. He comes out and, "How did it go? Did you learn?" and it was, I can't get interacted until I pick it up, look, and after that, read it and talk with him. But I guess you sent that in the parent emails. Right? While the child is on, this is a parent's job too, not long, it can't be more than like 10 minutes, of course, because even emails, people tend to not open them or put it aside then I forget, "Oh my gosh, it's Tuesday night. I didn't do this," or so that you can even say, "Next week, have your avocado ready" as a reminder. But maybe that's just me because I need more reminding. Maybe other people are on top of it. And then they know the parent is involved with it too. If they're going to come in that last 10 minutes. See that? You're part of it, and you're on board with what we're doing here. Not just stick them in a room and say, "Okay?" – Parent of a 12-year-old male

Two other parents suggested having pre-recorded sessions for parents to watch at their convenience:

> I think it's important for the parents to know what is being discussed. Because then that information could be followed up. You could do it, you do the handout. I think having that component, it's just sometimes a webinar – I don't know. I'm not sure I would say this is being a better way would be, like mini videos, like you have a little mini video that comes out and that it's a minute, 30 seconds. or something, like, "We talked about this, and I showed them this chart," and doing it that way. Maybe that's a better way. I'm not sure. That's just a suggestion. – Parent of a 15-year-old male

> Timing was difficult for me. 5PM is when I'm wrapping up things with my job and winding down with them. So, I don't know what ideal time would be, and I know it was a consistent time, and it was pretty significant. I don't even know what a good time or response would be. It's hard especially when you're dealing with schoolwork and everything about e-learning and also working in juggling time. The environment is difficult with time, being with the pandemic and whatnot and stuff, and how you can defeat it. A little bit more asynchronous as opposed to live will probably be helpful. It will at least allow me to budget my time and be there at whatever time I can jump into it. – Parent of a 17-year-old female

## Perceived Benefits

Adolescents and parents described a range of perceived benefits, including diet changes, healthy weight, knowledge/awareness, behavioral strategies/skills, self-efficacy, outcome expectations, outcome expectancies, and other lifestyle changes.

### Diet Changes

Parents mentioned that they observed changes in their children's eating habits related to self-regulation and willingness to try new foods.

**Self-regulation**. Self-regulation was an emergent theme regarding children's diets after participating in BALANCE. Parents discussed how their children were serving themselves smaller portions or talking about balancing out energy-dense food and beverage choices with nutrient-dense food and beverage choices. One parent mentioned that her daughter has not stopped eating sweets, but she has been better about leaving food on her plate rather than "overstuffing herself":

> She's had more of a feel for leaving stuff on her plate when she was done and not overstuffing herself and even saying no to some things. On the other hand, there's still some things she won't say no to and she does want things like cookies and sweets and this and that. It's probably because it's here and it's accessible. But the actual program itself and the content was fantastic. – Parent of a 17-year-old female

Another parent mentioned that she noticed several changes in her son's eating and activity habits, including reducing portion sizes from four to two slices of pizza and opting not to have dessert if he has a sweet tea:

> Instead of reaching for the four slices of pizza, he's only reaching for two, so that's a pretty drastic change for him…He is doing better with the diet. Like I said, he really is doing better with the diet, and he is really like catching himself. If he drinks a sugary drink, he won't ask for dessert later in the day, which is really like a big thing for him because usually he's like – because we don't really do a lot of – it's all water here, but every now and then, we'll go to the store, and he'll want one of those Arizona Mango

> cans. And so, if he drinks that, he won't ask for a dessert or cookie, he was just – he's like, "No, I had my tea today." – Parent of a 13-year-old male

An 18-year-old male mentioned that he had been eating less since participating in BALANCE. He said, "I've been eating less. I was eating a whole lot more before joining this."

One parent mentioned that her child had intentions to make diet changes related to self-regulation, but she did not describe the actions themselves. Intentions aligns with a construct of SCT, which describes goals of adding or modifying proximal or distal behaviors (Glanz et al., 2015). She said:

> Yes, I want to actually mention in [his] case, he will be more conscious if he is eating healthy or not. Like for example, he is a big fan of McDonald's, so I try to take him over there at least maximum once a week because I know it's not healthy, when he does like a good behavior, and I want to reward him for that, so we'll go to McDonald's. What I think that what is interesting is that he will say, "Okay, I will be going to eat McDonald's, but tomorrow I'm going to be really, really healthy." So, he will be more conscious that maybe that he is eating is not the right thing that the next day he will do a balance. I think I like that. – Parent of a 12-year-old male

**Willingness to try new foods.** Parents also discussed an increase in their children's willingness to try new foods after participating in BALANCE. Many parents mentioned fruit and vegetables when they talked about new foods. One parent of a 16-year-old male described, "At least you get him to think about carrots, and that's something I appreciate. He keeps telling me, that weekend I was really happy because he keeps like, 'Don't forget my carrots.' I'm like, 'Carrots, okay!'"

A parent of a 13-year-old male discussed an overall increased willingness to eat fruit and vegetables: "He tried broccoli, and he's just been more willing to eat vegetables. And he says things like, 'I need to eat more fruits and vegetables.'"

Some parents mentioned daily changes in their children's fruit and vegetable intake, as illustrated by the following quotes:

> Since he's been doing this program, I have been buying apples, and he seems like to eat two apples a day or sometimes even more. He didn't like the texture before, but now, I don't know what happened. It seems like he doesn't mind to eat apples. Just about four weeks ago. And every day he eats [apples], so I have to keep buying a lot of apples. – Parent of a 17-year-old male

> He's adding spinach and lettuce once or twice a day, which he had not done before. It is baby steps. Adding a little bit more fiber to his diet, a little bit of an apple, still the sugar. but I'm impressed that he's adding lettuce and spinach every day. – Parent of a 19-year-old male

Parents of the youngest participants discussed how they noticed very subtle changes in their children's willingness to try new foods, such as trying one bite of vegetables at dinner or trying one cracker or tasting a new sauce, as illustrated by the following quotes:

> Usually, he'll have a bagel with butter or cream cheese, or waffles with butter for breakfast. Or cereal. And one day, he asked for something healthier, and I made him eggs. And I was just surprised that he asked for something healthier. And he's been saying that he needs to try more vegetables and eat more fruits and vegetables. I know he tried broccoli a couple of times, and I can't remember what else. But he's tried a couple of new things. Usually, when I make dinner, I'll put just a very small bit of vegetables on his plate that we're eating like, a tablespoon or something, even if I know it's something he doesn't normally eat. And a lot of times he just doesn't touch it, but since he started this class, he'll like try one bite. And that was without me prompting him. – Parent of a 12-year-old male

> He has been a little more interested in what other people are eating in the house. Not that he's become very adventurous, but one day I was eating crackers, these almond flour crackers. He just was kind of looking and looking at the box. Then he walked over and stuck his hand and then tried one. So, I think it made him a little bit more open to the idea. – Parent of a 12-year-old male

> Actually besides being more conscious, he is more open to try new things. Like if I buy any different type of sauce or something like different, he will try it. Doesn't mean he will keep going or he will accept that. But at least he tries to put at least his finger. Like the other day I had this chicken. He will put his finger just to try it because he says, "I need to try new things," but he's not going to eat it. He is more open, and so that helped with developing flexibility. Flexibility to say, "I may not like it, but let me try it." Before he would say, "Ew, I'm not going to try that." – Parent of a 12-year-old male

One parent mentioned that she thinks her son would be more willing to try new foods if prompted:

> I get the feeling that if I asked him to try something, he would more likely try it, now that he has done this class. He did try baked potato during a lesson, and he found he liked that, so that was good. I think he would be willing to try others as long as they are not greens, and I think he would be willing to help out more if I prepped him. You know, he has to be prepped a couple of days in advance before he does anything. I think he would be more willing to try to help now that he has gone through the class. – Parent of a 14-year-old male

Adolescents also reported trying new foods after participating in BALANCE. A 19-year-old male said, "Let's see, like, for example I tried, I tried different things. I tried to make this pasta salad. It was good. It had chicken and cheese in it. The seasoning too was good."

**Knowledge/Awareness**

Adolescents and parents reported increased knowledge and/or awareness related to healthy eating as a benefit of participation in the BALANCE intervention. Knowledge was the most common benefit reported by adolescents. As an 18-year-old male summarized, "It gave me some big brain knowledge about certain foods. Big brain knowledge."

Many parents used the term "awareness" to describe related changes that they noticed in their children. For example, a parent of a 20-year-old male said, "He did look on the side of the milk carton to see how much sugar was in it. That was good. The chocolate milk. Because I've never before done that. No awareness before. So that was good."

One parent discussed this awareness related to mealtime schedules and mealtime environments, which were both discussed in Lesson 2:

> I wanted to see more like awareness of the need to eat better because he's really picky, sometimes having to ask him to eat because he can go without eating breakfast in the morning to dinner completely. But sometimes he just skipped food completely, so no calories intake. At least now, he's more aware. At least he comes out and make some popcorn or takes a little bit of fruit. He is more receptive to the timing when I said, "It's time to eat." He's more aware now that he has to eat, while he eats, not doing something else and going around here to sit with us and eat, and we're trying to make it the family kind of situation, putting the social component and enjoying of the meal. – Parent of a 16-year-old male

Parents also discussed knowledge related to portion sizes and whole vs. processed foods, which were covered in Lesson 4. One parent mentioned how her son was using his hand to represent portion sizes:

> The portion size thing. I forget. One day he was going like this [making a fist]. We were talking about something and he's like, "This much." It took me a second to figure out what he was talking about, but it's in there more. He's the kind of kid though that some things sink in a lot later. He'll come to me in a month and remember some detail you said. He's so funny. – Parent of a 12-year-old male

One parent who mentioned increased knowledge about healthy eating as a benefit of her son participating in BALANCE also discussed how he wasn't ready to make changes in his behavior:

> As a matter of fact, one concept that he did bring up again was when you have processed foods or if the food is not in its natural state versus when the food is in its natural state. I think he really grasped that concept and took it. Yeah. I mean, he'll talk about, like I said, he'll talk about how some of the foods are altered, you know? Like, "Oh, this is this is good because it's only a little bit altered," or something like that. So, I think he's thinking about it. He definitely gets the concepts. He definitely gets that. Actually taking the step in making the right decision, though, that's another story. – Parent of an 18-year-old male

**Behavioral Strategies**

Parents discussed an increase in their children's food preparation skills, which aligns with the SCT construct of behavioral strategies (skills), or abilities needed to successfully perform a behavior (Glanz et al., 2015). Some parents mentioned that their children continued to make guacamole after the activity in Lesson 6. For example, one parent said:

> Actually, my daughter, she asked me to buy avocado and tomatoes to make – I forgot what it's called that – guacamole – because I wasn't making it before. I like to eat avocado, just I put it in a lettuce. I mix like a salad or – but she really likes that. And she makes it herself. She loves it. And like I said, I would have never thought my daughter would like to eat avocado because she never like to try it before. But since she made it, then it inspired her to taste. And then she liked it, and now she makes it all the time. – Parent of a 14-year-old female

Some parents also mentioned that their children became involved in food preparation or asked to learn new food preparation skills after participating in BALANCE, as illustrated by the following quotes:

> For sensory reasons, he never wanted to touch like dough or anything, but since he started the class, we've made pretzels twice. And he rolled out the dough. The first time we made it, he kneaded the dough and rolled it out, and made the pretzels. But the second time, it was a different recipe, and the dough was too sticky, and he didn't really like it, so he didn't knead it. And he only made one or two pretzels, and I made the rest of them. He just wouldn't have done that before. – Parent of a 12-year-old male

> Because of the program, he asks me sometimes like, "How can I cook this? How can I do this?" Then I tried to involve him in the kitchen like, "We're going to do this." He learned to cook some pasta because he usually just put olive oil on it and that's about it with the pasta, and some Parmesan, so it was so easy. You put in the water, the pasta, and take it and that's it. Then he learned how to do some sausages and French Fries that we fry them in the air fryer. – Parent of a 16-year-old male

Adolescents also mentioned "making food" (18-year-old male) and "learning how to make guacamole" (20-year-old male) as perceived benefits of participating in BALANCE.

**Self-efficacy**

When discussing their perceived benefits of BALANCE, parents discussed that their children had greater confidence related to healthy food choices or food preparation, which aligns with the SCT construct of self-efficacy, or confidence in one's ability to perform a behavior to achieve an outcome (Glanz et al., 2015), as illustrated by the following quotes:

> I think he's more sure of himself when maybe he'll go take a drink, he'll think about, "Maybe I shouldn't have that it's sugary," or, where before, he just grabbed it and didn't even think about how much sugar was in it, or what it could do, and things like that. – Parent of a 12-year-old male

> She likes the idea of learning how to cook and food in general. So, I think that was beneficial, like when you did the little trail mix things or the guacamole, like all those things that are beneficial for her to realize like, "Hey, I can throw something together even with a few steps." – Parent of a 12-year-old female

> I like that he has confidence for his own initiatives, as tonight, "I'm going to make dinner" or help. And he doesn't mind. I tell him, "Make sure you cut a carrot and put

> some because I love carrots." And then I praise him. I like that he wants to be involved in cooking now, and he doesn't mind to put what he can in the dinner. – Parent of a 17-year-old male

Adolescents agreed that they felt confident continuing to practice what they learned from BALANCE. A 20-year-old male said, "Making guacamole is easy."

**Outcome Expectations**

Outcome expectations, a SCT construct related to judgments about the likely consequences of healthy eating (Glanz et al., 2015), was mentioned by some parents. One parent described how her son is now aware that there are positive outcomes of healthy eating:

> Well, I think that he is appreciating the repetition of the words about healthy nutrients and that kind of thing and that he will use the word healthy when he's talking about. He knows that I want him to eat healthy and he'll kind of use that as well. "When I eat healthy, something good is supposed to happen to me as a result." – Parent of a 16-year-old male

Other parents gave more specific examples, including the benefits of carrots or dairy, which were both discussed in Lesson 3 of the intervention. For example, another parent of a 16-year-old male said, "As I was telling you, he was very concerned about his eyes, so carrots was on top of the list there."

**Outcome Expectancies**

Outcome expectancies, a SCT construct related to values placed on the outcome of healthy eating (Glanz et al., 2008), was mentioned by some parents in the context of increased importance of healthy eating. The following examples illustrate how parents discussed their children's acknowledgement of the importance of making healthy food choices:

> As far as nutrition goes, he's aware of the importance of healthy eating. He might not necessarily know how to make that best choice himself, but he knows he can look at a nutrition label and that's going to give him some information about which is better and which is not so good. – Parent of a 16-year-old male

> He seems to be talking more about it and understanding more about, "Maybe I need to make better choices," not that he does, but I think talking about all of this. He's on a different mindset, and hopefully, it'll get better and better. Again, it's helped in very little baby steps, but certainly I'm really happy that we did this. – Parent of a 19-year-old male

**Healthy Weight**

Some parents mentioned weight as a concern, and two parents said that they noticed an improvement in their children's weight since participating in BALANCE. A parent of a 20-year-old male said, "He looks like he lost weight since the beginning. I don't know if that's from the biking or if he's just watching stuff better." Another parent said that she thought her son lost three pounds since starting the BALANCE intervention:

> So, I think he's like he lost like three pounds in eight weeks or something like that. I think he is like 115. He was like 118 I think when we first started, so in the eight weeks to two months, I think he dropped like three pounds. – Parent of a 13-year-old male

**Other Lifestyle Changes**

Parents mentioned other lifestyle changes in addition to diet-related changes, including increased physical activity, meditation, water intake, and family style meals. For example, one parent described a significant increase in her son's physical activity:

> He is outside on the scooter now every day, more than just once. So, we've noticed even his behavior, he gets behavior therapy 21 hours a week, him and his brother. So, literally for 42 hours a week, there are other people in this house, and they've all noticed him outside a lot more than normal. Usually, he'd just be locked in the video game all day, but he takes lots of breaks now and he spends more time outside on the scooter than he does in his room. And this [BALANCE] is the only thing that's different, so that's the only thing I can attribute it to. I mean, nothing else has changed… he's skate – and he's – what you call it, scootering a lot. He's walking. He'll go outside for walks. And then sometimes, if it's dark, he knows he's not allowed to use a scooter outside of the gate, so he'll just walk around the house, like outside around, so yeah, I mean, that's all, we've definitely seen that improvement ever since that exercise lesson. – Parent of a 13-year-old male

Another parent mentioned how her son has been exercising more often and meditating since participating in BALANCE:

> He has improved in his making exercise. He's not overweight, but we need him to do exercise to have better outlet for his mental health and also that anxiety. He is doing it now and he's more aware of that, some healthy habits. It's associated with your program also because he's saying, "I need to exercise now." He a couple of times surprised me telling me that he has been meditating and I said, "That's good."– Parent of a 16-year-old male

Some parents mentioned that their children have been more focused on staying hydrated. For example, a parent of a 16-year-old female said, "I know she talked about drinking more. She has been focusing trying to drink more, which is good. I think that helped with that like reinforce that for her. Yes, I think that right there was helpful."

Lastly, a parent of a 12-year-old male mentioned that she has been serving more family style meals since her son participated in BALANCE: "Your class made me decide to serve more of our meals family style at the dining table because I usually just fill up the plates myself and hand them out without really thinking about it."

## Unintended Consequences

### Anxiety/Discomfort

One parent and one adolescent mentioned anxiety or discomfort that occurred during intervention lessons. One parent discussed that her son had discomfort during lessons that caused him to engage in destructive behaviors like pulling his hair. Her son ended up turning off his webcam for most of the lessons so that he felt more comfortable. As this parent described:

> Just when he was frustrated and he didn't want to participate. It seemed like in the beginning, he was like really gung-ho, but then towards the end and maybe say like the last four lessons, he was just, he'd had a lot of like SIB [self-injurious behaviors] where he would kind of like pull his hair or the normal things that we would see during schoolwork. – Parent of a 13-year-old male

Another parent mentioned that her son was sometimes too tired or had a difficult day, but she said that she did not perceive his discomfort as a negative aspect of his participation. She said:

> I can't think of anything negative. It was more in the moment, like he's just too tired, or he had a difficult day, and it's kind of not over yet and that kind of thing. But no, nothing negative. I think it was definitely worthwhile. – Parent of a 12-year-old male

Her son left two lessons early because he was stressed or overwhelmed. During one lesson, he asked to take a break. When he came back to his computer after taking a break, he said, "Is it okay if I leave early? I'm just not into it today…I just feel too stressed today."

## Context

### Diet History

Emergent themes regarding children's diet history included Limited diet variety, Sensory challenges, and Routines and rituals.

**Limited diet variety.** When asked about their children's diet history, many parents reported that their children's diet variety was limited. Some parents said that their children basically eat the same foods every day. For example, one parent described:

> He eats almost the same thing every day. He eats… for breakfast he will have cereal, sometimes a protein shake to get started, so that is a little bit better, but then cereal. Lunch, he eats chicken strips, two corn dogs, and French fries every day. And then for dinner, he eats fish sticks, two corn dogs, and French fries every day. – Parent of a 14-year-old male

Another parent discussed how she brings her son's foods when they leave the house:

> Even before COVID, we did not really go to friends' houses for food, and when we do, I tend to bring my own food for him just to make sure he has something that he likes. Even for Thanksgiving, he does not eat anything basically that… we usually go to his grandfather's house. He does not eat anything that is made for Thanksgiving other than the rolls. He will eat the rolls. I bring his food with him for wherever we go. I am always… even at this age 14, I am, still feel like when he was a baby, you know… I would have to pack the cooler, and I still do that, so even if we are going places, I probably would be still doing it. – Parent of a 14-year-old male

One parent discussed how she allows her son to stick to his limited list of foods because it's easier for her:

> [He] has found a very limited list of foods that he will reliably eat and feel like he's getting something good to eat, and I allow him to continue to have that limited diet

> because it's easier for me. Years ago, I had tried doing kind of like a gluten-free thing, and I just found myself getting completely crazy trying to run around all over town shopping for these foods that really weren't very good anyway. – Parent of a 16-year-old male

Some parents discussed that their children's diet consisted largely of carbohydrates. As one parent described:

> It was pretty bad. He eats, he used to eat a lot of carbs, and that was like the only thing he would eat was carbs. Things like macaroni and cheese, cereal, bread all the time, all the time. He was gaining so much weight that even the doctor recommended that maybe we put him on like an appetite suppressant because he was eating all the time, and it wasn't like good food that he was eating. But we used to talk about it. I used to talk about it with him, but he just never really wanted to listen to me because, you know, mom. But I feel like even though he kind of, when he was taking the class, he was kind of like, "Eh," but he got a lot out of it, I think he did, just judging by the way that he's eating now and the things that he's doing now, he got a lot out of it. – Parent of a 13-year-old male

Some parents mentioned food allergies/intolerances or digestive issues as a contributing factor to their children's limited diet variety. One parent said that her son is worried about unfamiliar foods triggering his digestive issues:

> His diet involves a lot of cheese, a lot of bread, a lot of soda. Again, he is adding lettuce and spinach, which is big news. I mentioned to you that he had a lot of issues with digestive, IBS [Irritable Bowel Syndrome]. We're at a good place, but he's very nervous about spice because having had those issues, he worries that, "Oh my God. What if they come back?" – Parent of a 19-year-old male

Another parent mentioned that her daughter's diet is restrictive due to food allergies:

> [Her] diet is very restrictive in the sense of, she's got a lot of allergies that we try to manage. However, we do let her cheat. It's not so severe. She will get an upset stomach and things like that. She tends to eat the same things over and over. So, her diet is somewhat, in her mind, restrictive. – Parent of a 19-year-old female

**Sensory challenges.** Parents also discussed sensory challenges when describing their children's diet history. For example, one parent mentioned how her son goes into a different room when the family orders takeout to avoid smelling the food:

> Then sometimes if we get takeout, which we do maybe twice a week, [he] wants nothing to do with it. He goes in a different room. He doesn't want to smell it. He doesn't want to see it. He just nothing. He had a really hard time with Thanksgiving too. He just hated

> that food, but yeah. I can't think of anything I would have said to do differently really. – Parent of a 12-year-old male

> Parents also described issues with certain textures, as illustrated by the following quotes: His diet has always been very limited. He has very severe sensitivity issues. With the intervention of an ABA and some other motor therapy, we get him to eat and talk, but still have some residual of not being able to move all the food in his mouth. So, it's difficult for him to eat, and sometimes some textures that definitely he is going to reject. Generally, he likes crunchy things. He likes some salty, some sweet things then the proteins have to be really soft. – Parent of a 16-year-old male

> Yeah. I just wish he would, he has a lot of issues with textures. And so, because of that, a lot of times it's really hard for him to try new food, so we're really trying to work on that because really the only fruit he will eat is apples. – Parent of a 13-year-old male

**Routines and rituals.** Parents also discussed their children's routines and rituals involving food. For example, one parent of a 16-year-old male said, "We do Chick-fil-A once a week. That's his Saturday routine, so we've stuck with that for years now." Another parent described how her son likes to have his pizza cut a certain way:

> I will make sure like he has his pizza. He likes it chopped into 16 pieces, and then we will place it on the table for him, make sure he's got a fork and a napkin, and if he asks to have a drink, he's got to get his own drink. – Parent of a 16-year-old male

**Food Environment**

**Parent control.** The most common theme regarding the children's food environment was parent control, including parents restricting or allowing access to certain foods. One parent discussed how she locks away her son's preferred foods so that they are not readily accessible:

> I have all the snacky stuff locked in my closet, so there's nothing out for him to get. The one thing he does a lot, he drinks a ton of milk, like he has always drank milk, so we always have a lot of that in the fridge. I'll go to Sam's and I'll get the three pack. I always get the organic one. Even if I want him to make a peanut butter and jelly sandwich, for example, I'll get the low sugar jelly, and I'll get the organic peanut butter. Actually, there is one that he really, really likes, the vanilla almond butter. He'll make that for himself. But I have to lock up the peanut butter, so when he wants to make it, I got to get it out for him. Okay, so in fact, whatever is accessible to him is food that he doesn't prefer. Anything that's like in the fridge is pretty much stuff he, because I don't keep a lot of junkie desirable things in the fridge, like there's probably avocados in the fridge. There's probably like zucchini spirals. Maybe some fruit. Whatever's in the fridge, he's not going

to really care to have, to be honest. When it's time to eat, I will pull things out and make them for him. – Parent of an 18-year-old male

Parents also described how they only keep certain types of foods and beverages in the home, such as organic options. One parent said:

> Well, I also don't like to buy a lot of processed foods. We don't drink pop or soda, whatever you call it. As far as beverages, he just drinks water, milk, and orange juice, usually. I only let him have one serving of juice a day because I think it's too high in sugar. And our milk is raw milk. We started drinking raw milk in 2009, and ever since then, he doesn't like other milk as much. Although he will use it in, like if I get some milk from the store, he'll use it in his cereal, but he won't drink it. But he likes to drink water, and he drinks mostly water. I mean, I always have fruits and vegetables in the house, so he can eat them if he chooses, but he usually won't unless I prompt him. And he doesn't like a lot of them. He likes baby carrots with ranch, and if I cut up apples and give it to him with peanut butter. He'll eat a banana. We're omnivores. We eat all the stuff. As far as bread, I'm not eating bread right now, but I always have bread for him. I try to buy everything, like I try to buy organic bread and stuff because I worry about the pesticides on it. – Parent of a 12-year-old male

Another parent described how the whole family avoids certain types of foods, such as those with food coloring and artificial sweeteners. She said:

> For us as a family, I feel like we have a lot of healthy choices. We don't do soda. We don't do colors in our foods. We don't do artificial sweeteners. We don't do candies or cookies, or when she eats cookies, I take that back, she does usually have cookies available that are cookies that we make, but there's not a lot of other things present in our household because we just don't eat that way. As a family, we don't have that kind of lifestyle, I guess. – Parent of a 19-year-old female

Another parent mentioned how she limits the types of snacks that are available in the home for her son:

> He likes to eat his snack at night. Most of the snacks that he likes for nighttime are really unhealthy, like cheese and that type of things that have a lot of colors and have no any type of nutrition value, so I honestly, I stop buying it. I don't have that, and if he's hungry, he has like those fruit and nuts, or there is fruits, and I say, "That's what we have here. I don't have those other type of food. If you are hungry, this is what you need to eat." – Parent of a 12-year-old male

**Barriers to maintaining a healthy food environment.** Cost and lack of time were discussed as barriers to maintaining a healthy food environment. When describing the food environment at home, one parent mentioned how she limits her son's fruit intake due to cost:

> Overall, I'd say it's pretty healthy because we don't buy a lot of snacks that aren't healthy. We rarely have sodas. We rarely have chips. Given the opportunity, he would choose those, but since we don't have them, he's not. He does love fruit. He will eat three apples a day if we let him, but then apples get expensive when you're eating three a day, so he gets in trouble for eating all the apples. – Parent of a 16-year-old male

Another parent discussed difficulty feeding her family on one income. She also mentioned the lack of nutrient-dense choices available at food banks. She said:

> If someone can wave their magic wand, I would love for food prices to drop. With two teenage boys in the home, they do want to eat constantly, and sometimes, I feel bad because that's kind of part of teenagers. My brother walked around, my mom would yell at him still, but she didn't take it away, like a bag of chips…but it's hard, with especially one income, from feeding them the things that they like, and I think also too, then I even could provide more of the whole foods that they like as a snack. A friend of mine, long story short, I ended up with some Babybel cheeses, but that's not something that every week we're going to buy, because they're kind of expensive. You know what I mean, definitely food prices, if there was a food bank or something, you know what I mean, a lot of times they don't have the perishables. I feel like that's, I don't know what metaphor it is, but I just think it's sad that people who generally need food from the food bank, people talk about how they make poor food choices, but then that's what they're given, like canned goods. You know what I mean? Processed foods. And then you want to talk about the health issues. So, that's kind of… This what I can afford. You know what I mean? And it may not be the best that the pediatrician, well, I remember one time, said, "You need to include more fish." Okay, yeah, sure, I can afford that for a family of five on one income. I get it. We need that. It's healthy for us. And I did, well, I guess, once a week, or once every other week. It's more affordable and better than none. So, now we do have fish tacos. A little bit of fish. But it's just hard to eat healthy as we're supposed to, I guess, with limited funds. – Parent of a 16-year-old male

Lack of time was another common barrier to maintaining a healthy food environment. Several parents discussed how ordering pizza was part of their routine because it was convenient, as illustrated by the following quote:

> We order very often, especially since, because I work. When I work, I work 24 hours, so I'm not here for an entire day, so especially then it's super easy for my husband to just

> order pizza, you know what I mean? Honestly, like I told you, I'm not real big into cooking, so a lot of times, it's just easier to order out. – Parent of an 18-year-old male
> The only thing that set in concrete stone as far as takeout is pizza once a week, we call it Pizza Friday, because mom's not cooking nothing on Friday night, so we order one large pizza, and that feeds all four kids. They each get two slices. – Parent of a 13-year-old male

**Out-of-home food environment**. Most adolescents and parents mentioned that they had been eating most of their food at home due to COVID-19 restrictions, but some parents discussed the out-of-home food environment as a hindrance to healthy eating. One parent described how his daughter had been making worse food choices when she was attending school in person:

> She wasn't making the best choices. To me, it's a shame that they even made those bad choices available… I would think that there can be a little bit more control over that, but there isn't. She's getting the Rice Krispies bar every day and anything fried stuff for lunch. They probably can't tell her not to because there's too many young kids there to deal with. She goes to [high school]. It's a gigantic school in terms of population, and no one's going to be paying attention with a high school kid. – Parent of a 17-year-old female

Another parent discussed how the community food environment offers similar challenges:

> To the point where he can get stuff, and I don't know if I can curtail that or not. But again, I talk to him until he's blue in the face. "Let's eat it this today," or, "We can add this as a treat," but especially being teenaged too. He goes outside and walks the dog, and neighbors are like, "Hey, we had a party, you want six Pepsis?" So just, how do I curtail that? – Parent of a 16-year-old male

**Family Support**

Family support was an emergent theme regarding children's eating habits. Some parents described teaching their children how to prepare food themselves. One parent discussed how she encourages her son to take on food preparation tasks to help him build independence:

> We're trying to get him more independent. A lot of times I try to stop myself and say, "Okay, well, he can do this," or, "Here, [son], here, use… whatever it is." A lot of times, it's a frozen something. "You know how to use the oven. You go ahead." And I'll help him put it to 350. "And when the beeper goes off, you put them in the oven, and set the

> timer for 15 minutes." So probably two-thirds of the time, we're making it for him, but then one-third, he does himself. – Parent of an 18-year-old male

Other parents mentioned planning ahead and preparing healthy snacks or making them more accessible for their children, as illustrated by the following quotes:

> If I'm going to be gone for the day, not be here, I try to portion out and plan out, "Okay, here's your healthy snack. Here, eat some carrots and hummus," or, "Eat some watermelon or an apple," whatever. So, I try to plan it out. Then to make her more aware, "Okay, don't eat too many starchy snacks. You got to have some fruits and vegetables." I portion them out and leave them available for her so she can just go to the refrigerator and pull them out. – Parent of a 19-year-old female

> Reducing even the response effort of making stuff, making it easier to choose healthy food, putting it in front of the fridge, or already having it washed, or same thing with snacks. Putting the snacks upfront. Just making stuff easier to access than the non-preferred item. – Parent of a 14-year-old male

Some parents mentioned how family members were positive or negative role models for their children. A parent of a 17-year-old female said, "Her sister's like an athlete. She eats very healthy food, so she sets a really good example." On the other hand, some parents mentioned that they were interested in BALANCE because they felt that they were not positive role models or did not have the knowledge to support their children's eating habits. One parent said:

> I wanted him to learn something about nutrition because I'm not a great role model. So, I was hoping maybe he can, and I can learn too, and we can learn together, and he can take some, not responsibility, but want to do a little more, be a little out there because he would ask stuff and sometimes I didn't have an answer for him. – Parent of a 12-year-old male

**Changes Due to COVID-19**

Participants described the impact of the COVID-19 pandemic on children's health behaviors, including dietary behaviors, physical activity, screen time, as well as the mental health impact of the pandemic.

**Dietary behaviors.** Adolescents and parents described eating more food at home due to the COVID-19 pandemic, including snacks, homemade meals, and takeout or delivery. Most

adolescents reported that they do not go out or rarely go out to eat due to COVID-19. For example, an 18-year-old male explained, “I don’t really go out with my parents, because again, virus detected.” Regarding eating habits for their children, many parents mentioned an increase in unhealthy or problematic eating behaviors. Some parents reported that their children have been snacking more since COVID-19 started. A parent of a 20-year-old male said, “He gets more snacks because he’s home more. I buy more chips, popcorn, and crackers and stuff like that.” Another parent described:

> Because now, he’s home all day with a kitchen full of food. It has impacted his eating habits quite a bit, because at school, there’s scheduled times where they eat, but here, we have scheduled times where he eats, but it is right there, and he does his work here at the table. He’s looking right at the kitchen. Yeah, the pandemic did definitely put a damper in his eating habits. – Parent of a 13-year-old male

One parent mentioned that her son used to try more foods at school and work before the pandemic, and he has been less inclined to try new foods since the COVID-19 pandemic began.

> At school, he would have options to various foods to look at, and he would seem to maybe try something, where at home, he’s not eager to do that. He used to love broccoli, and he loves ranch dressing. He would eat a lot of broccoli and put ranch dressing on it. Now, the texture with broccoli and it being a little bit gassy, he doesn’t want to try it or eat it like he used to. He would dip carrots in ranch dressing. Now he’s not doing that, and again, that was a lot with school. Now, maybe we’ve taken a few back steps since COVID. I would definitely say he was trying a lot more foods pre-COVID, and he was so happy at his last job. He was so great. About food, that was so great because he would try things. – Parent of a 19-year-old male

Regarding eating habits for the whole family, parents reported an increased awareness of healthy eating due to eating more meals at home. While some participants mentioned that they started getting takeout and/or fast food more often, many reported that they have been making food at home more often. A parent of a 19-year-old male said, “Maybe two days a week, it would be something from home, and the rest something out.” On the other hand, a parent of a 15-year-old male described how her family has increased home cooking:

> I think for us, it really changed a lot of our food choices as a family because we're not eating out as much. And I'm working from home now, so we're most of the time better able to have home-cooked meals and that type of thing, which I think has been a really good thing for all of us just health wise and money wise. I think just we've just made healthier choices overall as a family and trying to also be able to sit down and have a family meal, where before the pandemic, we were running like, soccer game, food, and all of this kind of stuff. We're able to focus better on our eating and eating healthy and cooking dinner more, and I think overall for us from a health perspective, it has helped. – Parent of a 15-year-old female

Another parent described how her family has improved their awareness of what they're eating and reduced their fast food intake since the pandemic hit:

> We started minimizing the number of times we go to the grocery store, so we for sure don't go more than once a week. Originally, we were planning to not go every two weeks, and so we would have to stock up all that food that was going to last for two weeks and make sure that it was the kind of food that wasn't going to get rotten right away. That had an impact, and it kind of forced us to plan a little better. It has probably improved our awareness of what we were eating, and we were not getting the fast food stops. Prior to that, we were doing daily. So, we stopped. The McDonald's and the Burger King stopped. And occasionally, now, we'll get pizza from Domino's or something like that, and that's a big deal. Instead of that kind of daily expectation. – Parent of a 16-year-old male

**Physical activity.** Parents also reported that their children's physical activity habits have changed as a result of the COVID-19 pandemic. Many adolescents and parents expressed frustration or unhappiness over structured physical activity opportunities being canceled. As one parent explained:

> The physical activity. We joined a group, but then they canceled it, and it's outside in the park, but then the park shut down for a little bit for group activities. I think it is back on. He does yoga one day a week at the school, but then school shut down. Because one of the concerns of COVID, so that shut down. But they're still doing yoga online, but now it's over for two weeks, so I'm going to try to make an effort every day to say, "We need to get on the bikes." Again, we were doing that during the pandemic, and we stopped when he started school, but we'll try to get more active. But he's not in any type of sport or anything like that. – Parent of a 12-year-old male

Another parent mentioned that her son was unhappy about karate classes first getting canceled and then being offered online:

> We already led an isolated lifestyle, but we did count on those outside activities occasionally to be things that would kind of keep us going. At first, throughout the summer, for example, he was taking a karate class and that, of course, got canceled, and then they were doing the karate online. We learned how to do it online, and that that kind of worked out okay, but definitely, he vocalized a lot of, I wouldn't say frustration, but just unhappiness about it. I mean, he understood that was the reason. He kept talking about "Coronavirus is going to end." Every day he tells me the date that Coronavirus is going to end. He's kind of ready for it to be over, and he talks about that a lot. – Parent of a 16-year-old male

One parent mentioned how her son has not been able to participate in a variety of activities due to the pandemic and his pre-existing conditions, so his sedentary behavior and weight have increased:

> He used to do things after school. We did Krav Maga. He did a lot of activities. We had a lot of things lined up that they would do. Horseback riding. They had a lot of things to do. We had Busch Gardens passes, Adventure Island passes. We were a 'go family.' You could not catch us. We were at church, we were everywhere, but after this pandemic, we've been very much home bodied because of [my son's] pre-existing conditions, so we've been home a lot, and so that really impacted him. This is why he did gain quite a bit of weight when the pandemic started because all he was doing was sitting on his bed playing video games. – Parent of a 13-year-old male

Some parents discussed that their children and/or families have increased outdoor physical activity. One parent described how she and her son have been going for walks more often:

> He's been allowed more screen time, and at the same time, we have been more consciously making an effort to go outside and go for that walk, and he's willing to do that because it allows him to get out and see what's going on. He's interested in walking around in the neighborhood and stuff, so that's pretty good. – Parent of a 16-year-old male

Adolescents also discussed that they have been enjoying walking outside. One 19-year-old female said, "I like to go see wild pigs in my neighborhood," and a 16-year-old male said, "I like to walk with my mom. We go walk out like at a national park."

**Screen time.** Parents reported that their children have increased their screen time as a result of the COVID-19 pandemic for virtual school, appointments, socialization, and

entertainment. When asked about her son's screen time, one parent described how she tries to enforce the same rules that he had when he went to school in person. She described:

> He is on screens all the time. If he is not on the computer, he is on his cell phone. If he is not on his cell phone, he's with the TV. But sometimes what drives me nuts is that he has a TV and he's on the cell phone anyhow, so that's a bad habit that I have not been able to break. Now I'm making him aware, like, "When you're in school, the phone goes away. There's a reason why the teachers put it away. They do not let you have it at school." – Parent of a 16-year-old male

> One parent described how her son uses screens from the time he wakes up until 9:00PM: He is constantly on screens. Part of it is because of school, so he does not get the break for school since he is in online school, so he is literally from the time he wakes up – and he does not sleep well, never has – until probably nine o'clock at night he is somehow in some way on a screen. – Parent of a 14-year-old male

Parents also emphasized that a substantial amount of their children's screen time is productive or required. One parent mentioned that her son spends a lot of time on his computer for homeschool and therapy appointments:

> He's on the computer all day. He has three 30-minute sessions with his teacher per day. Then twice a week, he has OT [occupational therapy], and twice a week he has speech. Those are each half an hour, so that's another couple of hours in the week. Then, his science lesson is recorded, so he watches that on the computer. I'm trying to think what else. Social studies is something he looks at on the computer. We do have the option of using this little newspaper things instead, but he is not as likely do that on his own. The computer, I can say, "Okay, do two sections of this, and then you're done." I can't see him sitting down reading this little newspaper thing. So yeah, it is a ton of computer. – Parent of a 12-year-old male

Another parent described how his daughter uses her computer and tablet for educational purposes:

> She does the computer a lot, which is really hard because she goes on a computer in school. We think she uses her computer time somewhat constructively. She makes movies on her iPad, like movies and stuff. She's actually taking two classes in eLearning on digital animation and art. – Parent of a 17-year-old female

One parent reported that her son increased his screen time to 3-4 hours per day in addition to his virtual school because of the pandemic:

> School could be from like eight to, what do they go on til, nine to three? And then, later on, he'll go a few hours, at least three to four hours on, but a lot of times on his phone. He's watching movies or watching shows. I'm trying to get him to, if he wants to watch a movie, let's watch it on the big TV rather than sitting here crouched over in this little phone. So, we're trying to encourage that. Because I don't keep the TV on anyway, so, if he wants to watch them, he can watch it. But yeah, he's on a lot, I'd say an additional three to four hours or so to the school. So, that's a long time. Before all this happened, he was maybe an hour after school wasn't bad. – Parent of a 12-year-old male

Parents also reported that part of their children's increased screen time has been due to their use of gaming, instant messaging, and video conferencing as methods of socialization. A parent of a 14-year-old male described that her son's only contact with his peers is through online gaming. She said, "screen time has definitely increased, obviously due to schooling online, but also video game time substantially just because he has no other contact with his peers other than online gaming."

Another parent described how her son uses Discord, an instant messaging platform, to communicate with other gamers:

> He does get on an app called Discord. I do not know if you have heard of that, but that is where he can chat with his friends because, since they do not see each other, and most of his friends I do not even think live near here. They are probably across the country, but so, he does chat online with them that way. – Parent of a 16-year-old male

A parent of a 20-year-old male mentioned that her son has shifted to videoconferencing his friends via Zoom to maintain his social life: "He was not Zooming with his friends before the pandemic. Since all of his social activities stop, then they'll Zoom… He has more of a social life than I do. He Zoom calls with his friends probably for an hour or more [daily]."

**Mental health**. Some parents discussed mental health implications of the pandemic. Two parents mentioned that their children had anxiety about the possibility of exposure to COVID-19. As one parent discussed:

> He is anxious about COVID, and like, in March, when they shut everything down, he started doing his training with [a trainer] via Zoom. He did it on Zoom for a couple of

> months and then he started going back in the studio. But he just doesn't want to go places because of COVID where he could be exposed. I mean, I'm actually glad he's concerned about it. He's just a little more concerned about it than I am. I mean, I'm concerned about it too, but, and we haven't gone to church, like, we used to go to church every week. We haven't gone to church since February or March, and we don't go to the grocery store anymore. I just use Instacart. But we went to this outdoor thing, and we were going to watch his niece's dance. It was the [event]. And they had it set off like where you could social distance. It was outdoors, and we were wearing masks, but a lot of other people weren't wearing masks, and when [my son] and I got there, we saw that, and we left pretty quick. It made him very anxious. – Parent of a 12-year-old male

Parents also expressed concern over canceled opportunities that had been positive for their children's social and emotional health, including social opportunities and jobs. A parent of an 18-year-old male discussed how her son's weekly card-playing tournaments had been canceled: "He likes to play with those Yu-Gi-Oh! Cards. He used to go to a tournament once a week, which is a great thing, and it was like a social thing. But then when COVID hit, they quit doing them." Another parent discussed how her son lost his job as a result of the pandemic:

> He had a job at a restaurant and unfortunately due to COVID, not once but two jobs, they could not keep him right now. That's what he really wants to do. He wants to get a job, and [he] likes to be busy, and he likes to be around people. We're just waiting. – Parent of a 19-year-old male

In contrast to comments about anxiety, lack of social opportunities, and lost jobs for their children, one parent reported that staying home due to COVID-19 restrictions has improved her daughter's emotional regulation because she doesn't have to regularly transition between settings anymore.

> For me, in her behavior, the pandemic has really helped because it calmed all of our lives. Our life now. I have four kids, so it calms our life down, and her, what I saw from her, was just that calmness helped her better be able to regulate her emotions and be able to get her behaviors under control better because she didn't have all these competing forces and having to constantly switch. So overall, from all of that perspective, I have to say if there's a silver lining of the pandemic, that would be it. I think for us, it really calms us down. – Parent of a 15-year-old female

### Motivation for Participating

When asked about their motivation for participating in BALANCE, adolescents said they wanted to learn new things, interact with peers, or that their mom told them to participate. For example, a 19-year-old male mentioned how his mom told him to join, and he agreed that it was a good idea to learn about nutrition: "I was joining this because my mom told me to, 'cause like she wanted me to, so probably it was probably like in good spirits to do this and learn about what foods and all that." A 14-year-old male said that he was motivated by the social aspect: "One thing that I was hoping to get in here was to interact."

Most parents mentioned that BALANCE provided opportunities for both nutrition education and socialization when describing their motivation to participate. As a parent of a 17-year-old female described, "We want to give her this education. We want her to be aware of what she's eating, be aware of the options and choices and consequences and any additional knowledge and additional socialization is always a good thing." Other motivations mentioned by parents included the intervention was tailored for adolescents with ASD, had a virtual format, and there was no cost to participate. As one parent summarized:

> I just think it's a good life skill to understand, and it was online, and it was free. It was like, and it was for kids, for autistic kids, so that's always important, because I didn't have to worry. Although she is 15, she doesn't think like a 15-year-old, so really kind of having a program that was made for a child like her more than – but it kind of came at the right time. It was free and also with, and I don't know how it was with the group, but for us with homeschooling right now, you can't see kids all the time. – Parent of a 15-year-old female

## Outcome Evaluation

The following sections describe the results of analyses to compare pre- and post-test measures for psychosocial determinants of dietary intake, dietary intake, physical activity and sedentary behaviors, and anthropometric measures.

**Psychosocial Determinants of Dietary Intake**

There were 26 participants who completed the psychosocial survey at pre- and post-intervention. Results for mean comparisons were statistically significant ($p<0.05$) for three of the seven constructs measured. Post-intervention means were significantly higher for behavioral strategies ($p=0.010$), self-efficacy ($p<0.001$), and outcome expectations ($p=0.009$). There were no significant differences for situation, social support, outcome expectancies, or intentions. Pre- and post-intervention means for all seven psychosocial determinants of dietary intake are depicted in Table 11.

**Table 11. Pre- and post-intervention means for psychosocial determinants of dietary intake**

| Characteristic (Values) | Number of Questions | N | Baseline Mean (SD) | Post-intervention Mean (SD) | p-value |
|---|---|---|---|---|---|
| Behavioral strategies[a] (1-5) | 6 | 26 | 2.7 (0.5) | 3.1 (0.6) | 0.010* |
| Situation[b] (1-6) | 4 | 26 | 5.3 (0.8) | 5.4 (0.7) | 0.407 |
| Social support[a] (1-5) | 5 | 26 | 4.1 (0.7) | 3.9 (0.7) | 0.372 |
| Self-efficacy[b] (1-6) | 7 | 26 | 3.3 (1.0) | 4.0 (0.9) | <0.001*** |
| Outcome expectations[b] (1-6) | 5 | 25 | 4.9 (0.8) | 5.4 (0.8) | 0.009** |
| Outcome expectancies[b] (1-6) | 5 | 26 | 3.3 (0.5) | 3.3 (0.5) | 0.935 |
| Intentions[c] (1-4) | 5 | 26 | 2.6 (0.8) | 3.0 (0.7) | 0.077 |

SD = standard deviation; [a]Response options: Never, Rarely, Sometimes, Often, Always; [b]Response options: Strongly disagree, Disagree, Disagree slightly, Agree slightly, Agree, Strongly agree; [c]Response options: Not at all true of me, Not very true of me, Somewhat true of me, Very true of me; *p<0.05, **p<0.01, ***p<0.001

**Dietary Intake**

There were 22 participants who completed the FFQ at pre- and post-intervention. Post-intervention means for energy intake ($p=0.022$) and added sugar intake ($p=0.026$) were significantly lower than pre-intervention means. There were no significant differences for total fruit intake or total vegetable intake. Pre- and post-intervention means for total energy, added sugar, total fruit intake, and total vegetable intake are depicted in Table 12.

**Table 12. Pre- and post-intervention means for dietary intake**

| Characteristic | N | Baseline Mean (SD) | Post-intervention Mean (SD) | p-value |
|---|---|---|---|---|
| Energy (kcal) | 22 | 1740.9 (629.5) | 1481.4 (408.2) | 0.022* |
| Added sugar (tsp equivalent) | 22 | 11.4 (5.2) | 9.2 (5.2) | 0.026* |
| Total fruit (cup) | 22 | 1.8 (1.6) | 1.6 (1.4) | 0.211 |
| Total vegetables (cup) | 22 | 1.1 (0.6) | 1.0 (0.5) | 0.615 |

SD = standard deviation; *p<0.05, **p<0.01, ***p<0.001

**Anthropometric Measures**

There were 26 participants who completed virtual height and weight appointments at pre- and post-intervention. At baseline, the breakdown for each BMI category was: 2 underweight participants, 16 healthy weight, 3 overweight, and 4 obesity. BMI percentile and BMI z-score values were calculated for 25 participants aged 2-19 years. One participant was excluded from BMI percentile and BMI z-score calculations due to age greater than 19 years. Post-intervention means for BMI percentile (p=0.013) and BMI z-score (p=0.010) were significantly reduced compared to pre-intervention means. BMI z-score ranged -2.2-2.6 at pre-intervention and -2.8-2.5 at post-intervention. There were no significant differences in absolute BMI or obesity prevalence. However, at post-intervention, one participant had improved from obesity to overweight BMI category, one participant improved from overweight to healthy weight BMI category, and one participant improved from underweight to healthy weight BMI category. The post-intervention breakdown for each BMI category was: 1 underweight, 18 healthy weight, 3 overweight, and 4 obesity. Pre- and post-intervention means for BMI, BMI percentile, and BMI z-score and pre- and post-intervention obesity prevalence are depicted in Table 13.

**Table 13. Pre- and post-intervention means for anthropometric measures**

| Characteristic | N | Baseline Mean (SD) | Post-intervention Mean (SD) | p-value |
|---|---|---|---|---|
| BMI | 26 | 22.2 (5.3) | 21.8 (5.1) | 0.061 |
| BMI percentile | 25 | 54.8 (34.2) | 52.1 (34.2) | 0.013* |

**Table 13 (Continued)**

| | | | | |
|---|---|---|---|---|
| BMI z-score | 25 | 0.3 (1.3) | 0.2 (1.3) | 0.010* |
| | | **Prevalence n (%)** | **Prevalence n (%)** | **p-value** |
| Obesity | 26 | 5 (19.2) | 4 (15.4) | 0.500 |

SD = standard deviation; *p<0.05, **p<0.01, ***p<0.001

**Physical Activity and Screen Time**

Results indicated that screen time significantly reduced from pre- to post- intervention (p=0.037), and there was no significant difference in moderate, vigorous, or recreational activity from pre- to post-intervention. Pre- and post-intervention means for screen time and physical activity are depicted in Table 14.

**Table 14. Pre- and post-intervention means for screen time and physical activity**

| **Characteristic** | **N** | **Baseline Mean (SD) n=22** | **Post-intervention Mean (SD) n=22** | **p-value** |
|---|---|---|---|---|
| Screen time[a] | 22 | 5.6 (1.1) | 4.9 (1.4) | 0.037* |
| Moderate activity (min/day) | 21 | 35.1 (38.2) | 42.7 (51.6) | 0.270 |
| Vigorous activity (min/day) | 21 | 18.8 (38.4) | 9.8 (21.2) | 0.393 |
| Recreational activity (min/day) | 21 | 36.2 (51.6) | 24.5 (32.2) | 0.931 |

SD = standard deviation; [a]Response options: None, Less than an hour a day, 1 hour a day, 2 hours a day, 3 hours a day, 4+ hours per day; *p<0.05, **p<0.01, ***p<0.001

# CHAPTER V: DISCUSSION

## Research Summary

Adolescents with ASD are at an increased risk of unhealthy eating behaviors (Bandini et al., 2010; Marí-Bauset et al., 2014; Sharp et al., 2013) and weight gain (Kahathuduwa et al., 2019; Must et al., 2017). Many existing nutrition interventions in youth with ASD focus on either ameliorating food selectivity (Sathe et al., 2017) or managing weight (Healy et al., 2019). Intervention studies in adolescents with ASD that aim to manage weight have often used heterogeneous samples of adolescents with a range of disabilities (Healy et al., 2019) and therefore may not address ASD-specific challenges, including sensory differences (Hazen et al., 2014; Kern et al., 2006; Leekam et al., 2007) and rigidity during mealtime routines (Attlee et al., 2015; Gray et al., 2018; Polfuss et al., 2016).

This study examined the feasibility of a novel, theory-based nutrition education intervention that aims to improve long-term healthy eating habits in adolescents with ASD. There is a lack of nutrition interventions for adolescents with ASD that incorporate health behavior theory and examine psychosocial determinants of dietary intake, such as self-efficacy and outcome expectations. SCT has been used to develop and evaluate interventions for individuals without ASD (Vilaro et al., 2016). The purpose of this study was to examine feasibility and acceptability of a virtual implementation of BALANCE, a novel, SCT-based intervention, as well as preliminary efficacy of its outcome measures, including psychosocial determinants of dietary intake, dietary intake, and anthropometric measures.

The study used a one-group pretest-posttest design. Feasibility of the intervention was assessed with fidelity checklists and engagement records, and feasibility of evaluating outcome

measures was assessed by response rate, completion, and data quality. Acceptability, perceived benefits, and unintended consequences of the intervention were examined by adolescent focus groups and parent interviews. Preliminary efficacy of the intervention regarding psychosocial determinants of dietary intake, dietary intake, and anthropometric measures was assessed with a psychosocial survey, the Block Kids FFQ, and height and weight measurements, respectively. Quantitative data analysis included descriptive statistics, as well as Wilcoxon signed-rank tests and McNemar's test for pre-post comparisons of outcome measures. Thematic analysis was applied to qualitative data based on *a priori* and emergent codes.

## Discussion of Results

The results of this study indicate that BALANCE is feasible and acceptable to implement virtually, and that BALANCE may improve behavioral strategies, self-efficacy, and outcome expectations related to healthy eating immediately after the 8-week intervention, with promising results regarding added sugar intake and BMI z-score.

### Feasibility

The virtual implementation of BALANCE was feasible, with 88% attendance, high participation (rated 3.5 out of 4), 51.9% homework completion, 98.9% fidelity, and no major technical difficulties. Of the 29 participants who completed Lesson 1 of the intervention, 27 (93.1%) completed all eight lessons. The other two participants dropped out after Lesson 1, partly due to challenging behaviors during the lessons. Adolescents participated verbally and nonverbally, and field notes indicated that verbal and visual prompts successfully increased participant engagement. However, field notes also indicated that some adolescents were distracted by other devices during the lessons, pointing to the need for environmental guidance for parents or teachers in future implementations of BALANCE. Most absences on the fidelity

checklists were due to children not having food for the guacamole-making activity in Lesson 6, which may have been due to forgetting or due to the cost of ingredients, suggesting that fidelity may be improved by making the food available for students via delivery or pickup or through more effective parent reminders. There is a lack of virtual nutrition interventions for youth with ASD to compare findings on implementation. In-person nutrition interventions for youth with ASD report high fidelity, ranging 94-100% (Cassey et al., 2016; Cosbey & Muldoon, 2017; Marshall et al., 2015). Many others do not report fidelity (e.g., An et al., 2019; Dreyer Gillette et al., 2014; Hinckson et al., 2013; Miyajima et al., 2015; Ptomey et al., 2015). The fidelity checklists and engagement records were effective at capturing participant engagement and group dynamics, and completion of these instruments by research assistants allowed for objective measurement.

Response rate, completion, and data quality were high for the FFQ + PAS, psychosocial survey, and height and weight measurements. Baseline response rate was 100% with 98.9-100% completion, and post-intervention response rate was 92.6-96.3% with 99.5-100% completion. These findings are similar to those of virtual obesity prevention interventions for typically developing youth. For example, 93% of participants completed baseline and follow-up measures for a web-based obesity prevention intervention for adolescents aged 12-15 years (Chen et al., 2011). Data quality was high for 88% of matched FFQs, 84% of matched PASs, and 100% of the psychosocial surveys. FFQ and PAS data quality may be improved through research staff assisting adolescents in completion. Reasons for exclusion for the FFQs – daily energy intake less than 500 kcal and a straightlining response pattern – may suggest survey fatigue or lack of interest in completing the survey. Although response rate was high, 22.2% of participants at

baseline and 33.3% of participants at post-intervention reported technical barriers when trying to access the NutritionQuest FFQ + PAS, mostly due to Adobe Flash.

The high response rate, completion, and data quality for the psychosocial survey and the 100% response rate for height and weight measurements indicate that virtually implementing these measures is feasible for adolescents with ASD. Previous research has used electronic scales to send weight data to research or clinical centers, but research-grade options for scales range $80-130 (Krukowski & Ross, 2020). The findings of this study suggest that conducting virtual height and weight measurements as instructed by research staff (e.g., through Microsoft Teams) may be a feasible low-budget option.

**Acceptability**

The findings from focus groups and interviews suggest that a virtual implementation of BALANCE is acceptable to adolescents with ASD and their parents. Adolescents and parents both mentioned that they already had experience with virtual school and/or appointments and were comfortable with the virtual setting. However, two participants had difficulties logging into Microsoft Teams on their Chromebooks, suggesting that Chromebooks and/or Netbooks are suboptimal for interventions through Microsoft Teams. Other virtual platforms, such as Zoom, might be more user-friendly. Even though some adolescents and parents may prefer in-person formats, the virtual format was especially favorable due COVID-19 restrictions. The group setting was also perceived favorably; parents liked that their children saw other adolescents trying foods and talking about healthy eating.

Parents of adolescents aged 15 and older liked that BALANCE fostered autonomy and independence for their children. Youth with ASD may exhibit deficits in adaptive behavior, or the ability to function independently in one's environment (Farmer et al., 2018; Kanne et al.,

2011), and daily living skills may decrease after high school in young adults with ASD (Clarke et al., 2020). Parents' interest in children's autonomy/independence is especially notable given that the most common theme discussed by parents regarding their children's food environment was parent control, which contrasts with children's autonomy and independence.

Adolescents and parents also liked sensory components and interaction, which is notable given the sensory differences (Hazen et al., 2014; Kern et al., 2006; Leekam et al., 2007) and social impairments (Sharma et al., 2018) that characterize ASD (American Psychiatric Association, 2013). Parents of adolescents in this study reported sensory challenges when describing their children's diet history. Sensory components may be particularly important during the COVID-19 pandemic, as many children and adolescents lack sensory-related educational activities and interaction with peers due to virtual school or homeschool using virtual materials. Over half of the sample (51.8%) described their school as homeschool or virtual school. During parent interviews, nearly all parents indicated that their children were not attending school in person, regardless of the method of schooling chosen on the demographic questionnaire.

Parents indicated that the weekly homework assignments and parent handouts reinforced what was taught during intervention lessons. Although the parent component was perceived favorably overall, parents recommended that the parent webinars be replaced with 10-15-minute parent sessions at the end of each BALANCE lesson or brief, pre-recorded videos for parents to view at their convenience. Findings from the parent interviews indicated that many parents are busy with work and their children's school, especially as they have been adjusting to lifestyle changes due to the COVID-19 pandemic.

**Perceived benefits.** Many adolescents and parents mentioned diet changes and several themes that align with SCT constructs, including knowledge/awareness, behavioral strategies, self-efficacy, outcome expectations, and outcome expectancies, as perceived benefits of BALANCE. Healthy weight and other lifestyle changes were also mentioned by parents.

Self-regulation and willingness to try new foods were discussed regarding children's changes in eating habits. Self-regulation, or personal regulation of goal-directed behavior, is a construct that is included in addition to cognitive, behavioral, and environmental factors in SCT (Glanz et al., 2008; Glanz et al., 2015). As youth with ASD exhibit food selectivity, or consumption of a narrow range of foods (Bandini et al., 2010; Cermak et al., 2010; Marí-Bauset et al., 2014; Schreck et al., 2004; Sharp et al., 2018), willingness to try new foods is an especially important factor in improving healthy eating behaviors for this population. Parents of adolescents in our study indicated that their children have limited diet variety and a lack of flexibility regarding food choices, including routines and rituals, such as having pizza cut into 16 pieces. Parents noted that their children exhibited an increased willingness to try fruit and vegetables in particular after participating in BALANCE. Many parents reported that their children were making changes on their own, while one parent reported that her son might be more willing to try new foods if prompted rather than on his own.

Although participants were not asked specifically about SCT constructs, adolescents and parents mentioned knowledge/awareness, behavioral strategies, self-efficacy, outcome expectations, and outcome expectancies. These qualitative findings confirm the significant differences detected in pre-/post-intervention means on the psychosocial survey for behavioral strategies ($p=0.010$), self-efficacy ($p<0.001$), and outcome expectations ($p=0.009$) and indicate BALANCE shows promise at improving some psychosocial determinants of dietary intake.

When asked about perceived benefits, two parents reported that their sons lost a noticeable amount of weight during the BALANCE intervention. While quantitative findings confirm that BALANCE shows promise for helping participants maintain or achieve healthy weight, follow-up measures are necessary to determine longer-term impact.

Although BALANCE was designed to target dietary intake and psychosocial determinants of dietary intake, some parents mentioned additional lifestyle changes, including increased physical activity, meditation, water intake, and family style meals. The importance of hydration was emphasized in Lesson 5, and physical activity was emphasized in Lesson 7. Water intake was not asked about on the FFQ. However, pre- and post-intervention physical activity was assessed with the Block Kids PAS, and there was no significant difference between baseline and post-intervention means. Parents discussed that their children were frustrated or unhappy about structured physical activity opportunities being canceled due to COVID-19, suggesting that adding a physical activity component might be especially timely. Future iterations of BALANCE should incorporate physical activity in more lessons or add a separate physical activity component.

Parents were asked about the impact of BALANCE on their children rather than their families, but one parent still mentioned that her family had been incorporating family style meals since her son participated in BALANCE. Family style meals were discussed in Lesson 8 and in the parent webinars. In parent interviews, family support was an emergent theme regarding children's eating habits, indicating that the role of the family should be considered in future interventions. As parents play important roles as both providers and models regarding food and eating (Savage et al., 2007), future research should improve the family or parent component, as well as assess the impact of BALANCE on the parents or family.

**Unintended consequences.** Anxiety/discomfort during intervention lessons was identified as an unintended consequence of participating in the virtual BALANCE intervention. One parent reported that her son's discomfort and related behaviors such as hair pulling also occurred during schoolwork, and the other reported that her son was generally stressed. There were 22.2% of participants who reported anxiety as a co-occurring diagnosis, and some parents reported an overall increase in their children's anxiety due to COVID-19. A 2011 meta-analysis indicated that nearly 40% of children and adolescents with ASD have at least one comorbid DSM-IV anxiety disorder (van Steensel et al., 2011). Additionally, as prevalence estimates for social anxiety in adolescents and adults with ASD may be as high as 50% (Bellini, 2004; Maddox et al., 2015; Spain et al., 2016), with 16.6% prevalence of DSM-IV social anxiety disorder (van Steensel et al., 2011), the social interaction during BALANCE lessons may contribute to anxiety for many participants. Participants were allowed to turn their camera off if they felt uncomfortable during intervention lessons. Future interventions may want to consider similar accommodations for participants who have anxiety, such as allowing them to leave their camera off or turning their camera off for certain parts of lessons if they feel uncomfortable. Another option is to offer one-on-one lessons if any participant is uncomfortable with the virtual group setting.

Some parents also reported increased anxiety regarding COVID-19 exposure. Previous research has found increased anxiety among children with ASD and their caregivers during the COVID-19 pandemic, as well as decreased emotion management among children with ASD (Amorim et al., 2020). One parent in our study reported that her daughter had better emotional regulation since she did not have to transition between environments due to COVID-19 restrictions. It is well-known that youth with ASD struggle with changes in routine, including

transitions between activities (American Psychiatric Association, 2013). There is a need to further explore factors that may contribute to the differential impact of the COVID-19 pandemic on children and their families, such as pre-existing family vulnerabilities and family processes (e.g., communication, organization, and beliefs) that involve parent-child, sibling, parent-parent, and whole-family relationships (Prime et al., 2020).

**Preliminary Efficacy**

**Psychosocial constructs**. Post-intervention means were significantly improved for behavioral strategies ($p=0.010$), self-efficacy ($p<0.001$), and outcome expectations ($p=0.009$). Qualitative data from parent interviews also suggested that participants improved behavioral strategies, self-efficacy, and outcome expectations, as well as two other SCT constructs: knowledge and outcome expectancies. Quantitative findings did not indicate that outcome expectancies improved ($p=0.935$), but some parents mentioned outcome expectancies in interviews. There is a lack of nutrition interventions that measure SCT constructs in youth with ASD, but a previous SCT-based nutrition intervention for typically developing youth found increased outcome expectations and self-efficacy, as well as increased goal intentions, competence, and autonomy (Contento et al., 2010). As autonomy was mentioned by parents in our study, further research should investigate the impact of the intervention on autonomy. One virtual nutrition intervention for typically developing youth has also reported increased knowledge about physical activity and nutrition (effect size=.18, $p=0.001$) (Chen et al., 2011).

**Dietary intake.** Post-intervention means for energy intake ($p=0.022$) and added sugar intake ($p=0.026$) were significantly reduced, while there was no significant difference between pre- and post-intervention means for total fruit or total vegetable intake. During interviews, parents discussed improved self-regulation and portion control, as well as willingness to try new

foods, including fruit and vegetables. Parents mentioned that their children were consuming less sugar-sweetened beverages and processed foods, such as cookies and "sweets." Many parents who mentioned that their children were trying more foods mentioned subtle changes, such as incorporating spinach or lettuce each day, or trying a bite of vegetables at dinner.

Fruit and vegetable intake may be more challenging to address than added sugar intake, as it often requires that parents purchase more fruit and vegetables to have available in the home. During parent interviews, cost was mentioned as a barrier to maintaining a healthy food environment, pointing to a need to address food insecurity in efforts to improve healthy eating habits in this population. For example, one parent discussed that she limits her son's fruit intake due to cost. Parent control was another emergent theme regarding the food environment, including parents restricting or allowing access to certain foods. Previous research has found increased use of restriction, pressure to eat, and monitoring during the COVID-19 pandemic (Adams et al., 2020). Finally, as the Block Kids FFQ may have stronger validity for nutrients than food groups in typically developing youth (Cullen et al., 2008), there may be limitations posed by the instrument.

Several SCT-based interventions have been effective at improving dietary behaviors in typically developing adolescents (Contento et al., 2010; Cullen et al., 2013; Freedman & Nickell, 2010; Mihas et al., 2010). The findings of this study are similar to findings of Contento and colleagues, which found that participants consumed fewer sweetened beverages ($p<0.001$) and packaged processed snacks ($p<0.005$) but did not find increased fruit or vegetable intake at post-intervention (Contento et al., 2010). However, other studies on SCT-based interventions have found improvements in fruit and vegetable intake. A study on SCT-based nutrition workshops conducted in a library setting found that milk, vegetable, and water intake significantly improved

at a 3-week posttest ($p<0.05$) (Freedman & Nickell, 2010), while another study found significantly increased fruit intake ($p<0.05$), as well as poultry and breakfast cereal intake, at 15 days post-intervention (Mihas et al., 2010).

Virtual nutrition interventions have shown promise at improving fruit and vegetable intake in typically developing adolescents (Chen et al., 2011; Cullen et al., 2013; Di Noia et al., 2008). One study of a web-based SCT-based intervention found that the percentage of adolescents who reported consuming three or more servings of vegetables per day at post-intervention was significantly higher in the intervention group than the control group ($p<0.05$) (Cullen et al., 2013). A study of a computer-mediated intervention conducted with economically disadvantaged African American adolescents found that fruit and vegetable intake significantly increased in the intervention group ($p<0.001$) (Di Noia et al., 2008). A study of a web-based childhood obesity prevention conducted in Chinese American adolescents found that more adolescents in the intervention group increased their fruit and vegetable intake than in the control group (effect size=0.14, $p=0.001$) (Chen et al., 2011). One web-based intervention for college students reported improvements in fruit and vegetable intake at post-intervention ($p=0.001$) (Kattelmann et al., 2014).

**Anthropometric measures.** Post-intervention means for BMI percentile ($p=0.013$) and BMI z-score ($p=0.010$) were significantly reduced compared to pre-intervention means. One participant improved from obesity to overweight BMI category between pre- and post-intervention height and weight measurements, but the difference in obesity prevalence was not statistically significant from pre- to post-intervention. During parent interviews, two parents reported that their sons had lost a noticeable amount of weight by the end of the 8-week intervention. These findings are surprising given the short timeline of the study.

A systematic review of SCT-based obesity intervention programs among adolescents found that BMI was significantly reduced in two of eight randomized controlled trials and two of four quasi-experimental studies reviewed (Bagherniya et al., 2018). The statistically significant improvement in BMI z-score in this study is promising, but there is a need to examine the efficacy of the BALANCE intervention in larger sample compared to a control group and include long-term follow-up measures. In the theoretical framework (Figure 1), psychosocial constructs are depicted as intermediate changes before changes in eating habits and weight status. Follow-up measures are necessary to determine the impact of the intervention on eating habits and anthropometric measures.

**Physical activity and screen time**. There were no differences in pre- and post-means for moderate, vigorous, or recreational physical activity. There was a statistically non-significant increase in moderate activity, and there were statistically non-significant decreases in vigorous and recreational activity from pre- to post-intervention. During interviews, parents discussed cancellations or changes in physical activity programs/lessons due to changing guidelines in response to the COVID-19 pandemic. Changes in physical activity due to participation in the intervention were not expected. Physical activity and sedentary behavior were discussed in Lesson 7, but there was no physical activity component to the BALANCE intervention. Screen time was significantly reduced at post-intervention ($p=0.037$), which could have been influenced by BALANCE lessons or due to external factors, such as having more offline schoolwork as the school year progressed. Some parents mentioned that their children made various lifestyle changes since participating in BALANCE, including spending more time outside.

During interviews and focus groups, participants discussed physical activity and screen time in the context of the COVID-19 pandemic. Adolescents and parents reported decreased

structured physical activity opportunities and increased screen time due to COVID-19 restrictions, which is consistent with previous findings (Garcia et al, 2020). On the other hand, sleep was not discussed as a major behavioral concern. The mean reported hours of sleep per night was 8.5 hours, which is within the recommended range (Paruthi et al., 2016; Watson et al., 2015). However, the low end of our reported range (6 hours) indicates that some adolescents are not getting enough sleep, which is expected, as the literature shows that sleep disturbances are common among youth with ASD (Cohen et al., 2014). Although the pre- and post-intervention measurements for this study were taken in an 8-week period, the broader context of the COVID-19 pandemic should be considered when interpreting findings.

**Strengths and Limitations**

The use of a novel, theory-based nutrition intervention developed specifically for adolescents with ASD was a strength of the study. The BALANCE intervention was developed based on formative research with adolescents with ASD and their parents, as well as evidence-based strategies for individuals with ASD (Goldschmidt & Song, 2017; Kluth & Darmody-Latham, 2003), theory-based activities (Perry et al., 1997), and nutrition education activities for children (Koch & Contento, 2011). The BALANCE intervention was designed and adapted based on two years of preliminary research, aided by perspectives and feedback from adolescents with ASD and their parents and teachers. Application of health behavior theory has been reported as a contributing factor to successful online nutrition education interventions (Ajie & Chapman-Novakofski, 2014; Murimi et al., 2019). The use of Social Cognitive Theory to guide the intervention contributed to high transferability, and the use of the RE-AIM framework allowed for a multidimensional evaluation of the intervention implementation to guide future implementations of the BALANCE intervention.

The mixed-methods approach and data quality assurance strategies were additional strengths of the study. The use of multiple data types contributed to high credibility. Data source triangulation allowed for comprehensive understanding of intervention feasibility, acceptability, and preliminary efficacy (Carter et al., 2014). Quantitative instruments had previously been validated for typically developing adolescents, and a three-stage process of screening was used to ensure high quality of quantitative data (Broeck et al., 2005). Participants' completion of study instruments virtually without assistance from the research team also reduced potential for social desirability bias in quantitative data. Rigorous measures were also taken to ensure high quality of qualitative data. To ensure high dependability, research assistants who were not involved in the intervention implementation completed fidelity checklists and engagement records to provide an objective measurement. A research assistant also double coded 15% of the qualitative data to determine interrater reliability. Systematic documentation via field notes throughout implementation lead to high confirmability.

This research built on a school-based feasibility study of BALANCE by making the intervention accessible to adolescents who attend various types of school, including public school, private school, and homeschool. Parents mentioned a range of strengths regarding the virtual format, including that their children were already familiar with online learning, there was no added time to travel to and from lessons, and parents could be nearby in case their children's behavior needed to be controlled during lessons. One parent explicitly mentioned that nutrition is often pushed aside since there are competing priorities, including appointments with numerous specialists. The virtual implementation of the BALANCE intervention made nutrition education easily accessible for participants.

Despite the benefits of the study, there are several limitations to consider. A major limitation posed by the study timeline is the lack of follow-up measures. Long-term impact of the intervention on psychosocial determinants of dietary intake, dietary intake, and anthropometric measures is unknown. Furthermore, the RE-AIM framework could not be applied in its entirety, as the lack of follow-up measures prevented assessment of the Maintenance dimension. Additionally, as this was a feasibility study, there was no control group with which to compare differences in pre- and post-intervention means. To examine the efficacy of the BALANCE intervention, a randomized controlled trial with long-term follow-up measures is necessary.

Other study limitations include low generalizability and potential for bias. Due to the small sample size, the findings of this study cannot be generalized to all adolescents with ASD, but the outcomes from this study can be used to estimate sample sizes and statistical power for future studies. Additionally, the study did not successfully reach adolescents with ASD who have low social communication skills. Of the 27 participants who completed the 8-week intervention, 26 (96.3%) had high social communication skills. The feasibility, acceptability, and preliminary efficacy of the BALANCE intervention should be further examined among adolescents with ASD who have low social communication skills. Furthermore, parents of both adolescents who dropped out after Lesson 1 reported their children's challenging behaviors as a reason for dropping out, suggesting that more assistance and supports are required to ensure that children's behaviors are not barriers to participation in a virtual intervention.

Due to the methods of data collection for the study, there is potential for self-report bias, recall bias, and social desirability bias. The FFQ + PAS asks participants to recall behaviors in the past week, and the psychosocial survey has questions about the past three months. Although data quality was high for the majority of FFQ + PASs and all psychosocial surveys, future

research should further explore feasibility and bias regarding the instruments used for this intervention. While the FFQ and psychosocial survey were pilot tested in a sample of adolescents with ASD as part of the formative research for this study, both instruments were developed for use in typically developing adolescents. Test-retest reliability of the FFQ + PAS and psychosocial survey should be examined in a sample of adolescents with ASD. Lastly, interviews and focus groups were conducted by the same individual who implemented the intervention, which may have impacted participants' responses. However, neutral phrases were used on focus group and interview guides (Appendix D) in an effort to reduce bias.

### Implications for Research, Practice, and Policy

As youth with ASD often work with interdisciplinary teams of care, this research may impact public health professionals, educators, and administrators of programs for children with ASD and other special needs. This study addressed the core public health function of assessment by investigating dietary and lifestyle behaviors in adolescents with ASD with the long-term goal of contributing to a solution for the health problem of increased obesity risk in this population. Although previous studies have established an increased risk of obesity in youth with ASD (Kahathuduwa et al., 2019) with unhealthy eating behaviors as a risk factor (Dhaliwal et al., 2019), there is a lack of research applying SCT to investigate determinants of dietary intake in this population. The theoretical framework of the current study, informed by SCT, helped to identify target areas for future interventions by monitoring not only dietary behaviors but also their determinants in adolescents with ASD, including behavioral strategies, self-efficacy, and outcome expectations. If the future efficacy study of BALANCE indicates that the intervention is effective at improving healthy eating behaviors and their determinants, BALANCE may be disseminated in virtual school or homeschool settings.

Future research plans involve (1) tailoring the intervention for more specific age groups (e.g., 16-20 years); (2) examining efficacy of the intervention compared to a control group and including follow-up measures to detect longer-term outcomes; and (3) improving the intervention to include multiple components, including a physical activity component and eventually organizational components, such as school food environment policies, which have been shown to improve dietary behaviors, including fruit and vegetable intake, in typically developing youth (Micha et al., 2018).

A long-term goal of this research is to develop a plan to support the health of adolescents with ASD through community partnerships. Partnerships are key to successful adoption, implementation, and sustainability of the intervention (Valente et al., 2015). Large-scale dissemination of BALANCE will rely on existing coalitions, collaborations, partnerships, and their key stakeholders and allies. By leveraging systems or connections that are already in place, future efficacy study of BALANCE will present another opportunity and pathway to connect these individuals and groups. Next steps include modifying and testing BALANCE as a multicomponent, multi-level intervention with a physical activity component and an improved parent-training component, and the subsequent development of a toolkit for use in virtual school settings.

Implications for public health research and practice related to virtually implementing nutrition interventions for adolescents with ASD, efficacy of the BALANCE intervention, the theoretical framework for the study, age-appropriate intervention strategies, external factors related to dietary intake, and the impact of the COVID-19 pandemic are discussed below. In addition to considerations for future research and practice, a dissemination plan has been

developed to share the findings of this study with research and community audiences (Appendix E).

**Feasibility and Acceptability of a Virtual Intervention**

The feasibility and acceptability of a virtual intervention for adolescents with ASD has substantial implications for research and practice. This research suggests that a small group virtual setting may be appropriate for many adolescents with ASD. Of the 29 adolescents who participated in Lesson 1, 27 adolescents completed the 8-week intervention. Many adolescents were engaged and attentive throughout the lessons, and visual and verbal prompts were effective at encouraging participation. There were no major technical difficulties, but minor technical difficulties were likely inevitable due to variations in internet connection speeds and the number of participants in each Microsoft Teams meeting for the lessons.

The findings of this study suggest that many elements of the intervention are appropriate and may be incorporated in future virtual programs and services for youth with ASD. Participants reported that they were comfortable with the virtual format, and the interactive group setting was perceived favorably. Participants liked having multiple components (e.g., weekly lessons, parent handouts, and homework activities) that reinforced each other. Sensory components, including hands-on activities and visual reinforcers, were also perceived favorably. Findings also indicated that programs and services should emphasize autonomy and independence for adolescents with ASD aged 15 years and older.

The successful implementation suggests that the BALANCE intervention and other virtual interventions may be appropriate for many adolescents with ASD. One parent reported that it was because the intervention was virtual that she decided to participate. Virtual settings may be especially advantageous for nutrition interventions for this population, as individuals

with ASD have competing priorities, such as Applied Behavior Analysis, occupational therapy, speech therapy, and physical therapy.

**Effectiveness of the BALANCE Intervention**

The findings of this study suggest that the BALANCE intervention has potential to improve dietary intake, psychosocial determinants of dietary intake, and anthropometric measures in adolescents with ASD aged 12-20 years. Future research should examine the efficacy of the intervention compared to a control group and include follow-up measures to detect long-term outcomes of the intervention. As one systematic review of computer- and web-based nutrition interventions for youth indicated that diet-related changes were often not maintained at follow-up (Hamel & Robbins, 2012), one or more booster sessions may be necessary to see long-term changes in eating habits.

Based on the findings of this study, the psychosocial survey and the Block Kids FFQ + PAS are feasible to scale up for large-scale dissemination. The Block Kids FFQ has been used in multiple settings (e.g., Au et al., 2012; Hunsberger et al., 2015), including large-scale randomized controlled trials (Trude et al., 2016). The school-based pilot study of BALANCE indicated that the Block Kids FFQ had a higher response rate, completion, and quality, as well as a lower participant burden, compared to 3-day food records. Parent measurement of height and weight as virtually instructed by research staff may be used an alternate method if in-person measurement is not feasible. However, results for assessment of anthropometric measures should not be generalized to other populations, and the virtually guided parent measurement approach should be tested in other populations.

The qualitative results highlight several areas to improve in order to maximize intervention effectiveness. Parents suggested that more visual reinforcers would be helpful for

their children, including sending printed cards and a USDA MyPlate poster to each adolescent along with the lesson booklet. Additionally, findings from the field notes suggest that, even though participants were engaged and attentive and responded well to visual and verbal prompts, many were distracted by other devices during the intervention lessons. Future implementations should enforce rules about no devices via communication with both parents and adolescents to maximize participation and intervention effectiveness.

Additionally, increased physical activity was mentioned as a perceived benefit of participating in BALANCE, but there was no observed improvement in any of the three types of physical activity measured by the PAS. As combined interventions that include nutrition and physical activity modifications are more effective at preventing obesity than single-component interventions (Psaltopoulou et al., 2019), future research on the BALANCE intervention may incorporate a physical activity component to improve its effectiveness.

The parent component should be further developed based on parent feedback to maximize intervention effectiveness. Increased parent support may help to improve adolescent engagement, as some adolescents forgot ingredients for the guacamole-making activity, did not complete all homework assignments, or were distracted during intervention lessons. Parents suggested having short, asynchronous videos or inviting parents to attend 10-15 minutes at the end of each lesson. Social media or text messaging may also be leveraged to increase parent engagement. If enough budget can be allocated, a website may be developed so parents can easily access all information related to BALANCE in one place. The home food environment is a key factor in driving children's dietary behaviors and weight status (Rosenkranz & Dzewaltowski, 2008). Findings from parent interviews indicated that many families are eating more foods at home during the COVID-19 pandemic, including processed foods, home-cooked

meals, and take-out, suggesting that the home food environment may be even more important to address in times of crisis, such as the pandemic. Obesity and overweight eHealth interventions for children and adolescents that use parents as agents of change show promise at improving dietary outcomes but not BMI z-score (Hammersley et al., 2016). The theoretical framework for BALANCE (Figure 1) assumes adolescents as the agents of change. The parent component should be improved but should not become the primary focus of the intervention.

**Modifications to the Theoretical Framework**

The findings regarding self-regulation and autonomy suggest that future versions of the BALANCE intervention should incorporate self-determination theory (SDT) (Ryan & Deci, 2000) to improve adolescents' intrinsic motivation to make healthy food choices. Emergent themes during parent interviews included that adolescents improved self-regulation after participating in BALANCE and that parents particularly liked that BALANCE encouraged their children's autonomy and independence. SDT assumes that human behavior is driven by basic needs for autonomy, competence, and relatedness, which are supported by one's social environment (Ryan & Deci, 2000). According to SDT, healthy growth and development requires satisfaction of these basic needs, along with a supportive social context. Autonomy refers to active participation in one's own behavior; competence refers to capability of controlling the environment and predicting outcomes of behaviors; and relatedness refers to connection to and care for others. SDT asserts that self-determined behavior is intrinsically motivated and intrinsically regulated, and that intrinsic motivation is enhanced when autonomy, competence, and relatedness needs are met. Previous research has successfully incorporated SCT and SDT (Contento et al., 2010) to improve behavioral obesity risk factors in typically developing youth.

Based on the results of this study, further research on the BALANCE intervention should incorporate constructs of self-regulation and autonomy. Future studies should conduct mediation analyses to examine whether factors based on SCT and SDT mediate the relationship between the intervention and behavioral outcomes. Given that screen time was significantly improved at post-intervention in this study, screen time should also be explicitly addressed in the framework. Lastly, the Environmental Context should be relabeled as Supportive Social Environment given the central tenet of SDT that autonomy, competence, and relatedness must be embedded in a social supportive environment to promote healthy growth and development (Ryan & Deci, 2000). The suggested framework for future research on BALANCE is depicted in Figure 3.

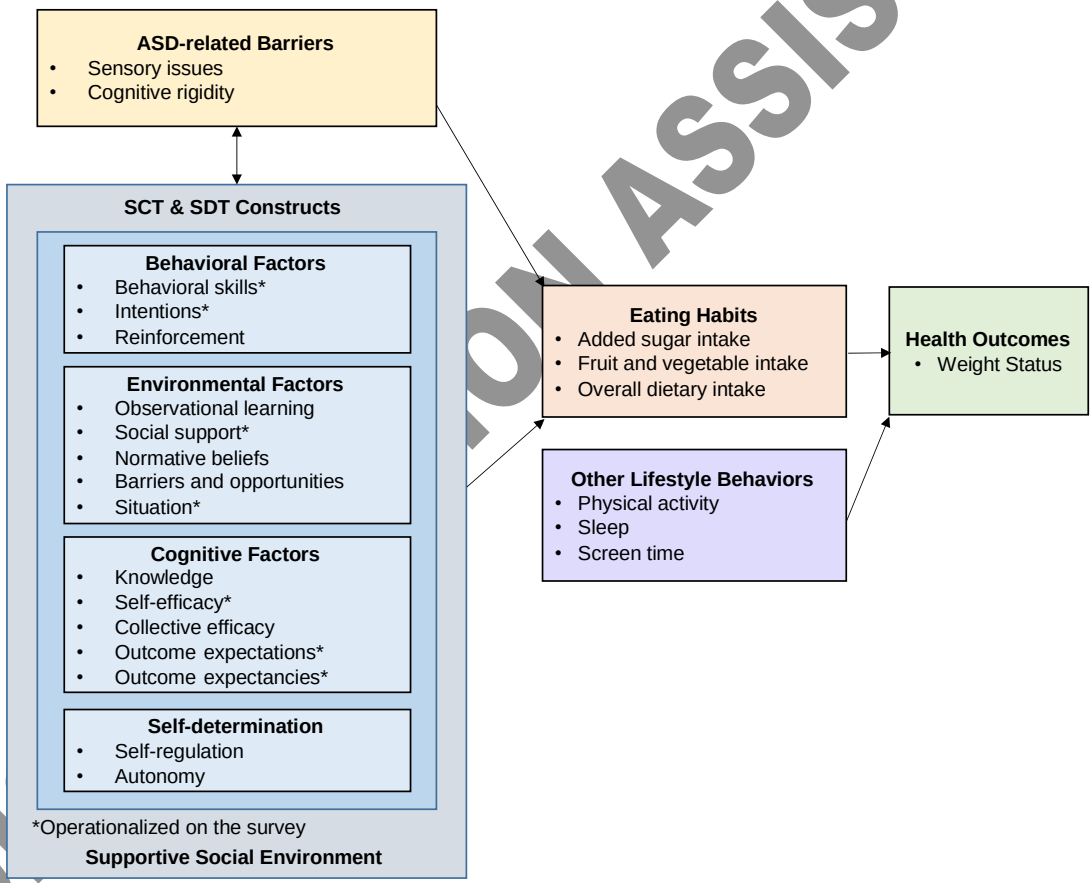


**Figure 3: Modified theoretical framework**

**Age-appropriate Strategies**

Successful nutrition education interventions for children include multicomponent, age-appropriate approaches (Murimi et al., 2018). This feasibility study included a broad age range, with adolescent participants aged 12-20 years. While the live implementation allowed for individualized feedback, further iterations should tailor the intervention activities for specific age groups, e.g., including a stronger focus on food preparation for adolescents aged 15 years and older. Parents of adolescents 15 years and older discussed not only that they valued how BALANCE addressed autonomy/independence but also that autonomy/independence is an overarching concern for their children. Additional activities for this age group may focus on food preparation and food safety, grocery shopping, and meal ideas. For younger adolescents, the parent component may be strengthened through low-burden methods, such as pre-recorded videos or an informative website. Findings of this study indicated that 12-year-old participants could not complete the homework on their own, and the homework was perceived as a burden by their parents. The homework assignments should be simplified, reduced, or eliminated for younger adolescents.

While participants perceived the group setting to be a strength of the intervention, one parent mentioned that the group setting could be improved by creating groups based on ability or age level. Although participants were screened for ASD behaviors via the ABI-S, groups were created based on participants' weekly availability for convenience. Tailoring the intervention by age group may help to increase engagement and effectiveness. Additional assistance and supports may also be required to reduce challenging behaviors during lessons for some adolescents, such as having more implementation coordinators or a lesson facilitator or encouraging parents or aides to be present in the room with adolescents when they participate.

**External Factors Related to Dietary Intake**

Qualitative findings point to external factors related to dietary intake among adolescents with ASD that warrant further investigation and consideration in interventions aimed at improving dietary behaviors. Specifically, the food environment was discussed during parent interviews as a factor that may impact children's food choices. Parent control regarding food access or restriction was commonly discussed, as well as barriers to maintaining a healthy food environment. Although the BALANCE intervention focuses on adolescents as agents of change, parenting practices can influence eating behaviors, particularly among early adolescents (aged 10-14 years) (Reicks et al., 2015), and parents may exhibit increased use of restriction, pressure to eat, and monitoring during the COVID-19 pandemic (Adams et al., 2020). Cost and lack of time were reported as barriers to maintaining a healthy food environment that should be further explored, especially as food insecurity may be exacerbated by the COVID-19 pandemic (Adams et al., 2020). Since many participants reported spending more time at home due to the COVID-19 pandemic, the findings of this study may not adequately highlight school or other out-of-home environmental factors that need to be considered when developing, implementing, and evaluating nutrition interventions for this population.

Family support was another emergent theme that should be further operationalized and measured in future research. For example, parents mentioned their role in teaching their children to prepare food or helping them plan meals or snacks. Some parents felt ill-equipped to support their children, suggesting a need for nutrition education and guidelines for parents of adolescents with ASD so that they can adequately support their children. Future research should further investigate parent, sibling, and whole family support for healthy eating behaviors among adolescents with ASD. Furthermore, professionals who work with youth with ASD and their

families should ensure that parents and families play an appropriate role in service delivery to encourage positive dietary behavior change for their children.

**Impact of the COVID-19 Pandemic**

Examining the impact of the COVID-19 pandemic on youth with ASD and their families was not a primary aim of this study, but emergent themes from qualitative data highlighted changes due to COVID-19 related to dietary behaviors, physical activity, screen time, and mental health. There is evidence for changes in eating behaviors and physical activity, as well as weight gain, among children, adolescents, and young adults due to COVID-19 restrictions (Stavridou et al., 2021). Youth with ASD have unique dietary challenges, including food selectivity (Marí-Bauset et al., 2014) and difficulties related to mealtime locations (Gray et al., 2018) that may be exacerbated by COVID-19 restrictions. Physical activity and screen time in adolescents with ASD may be worsened by the pandemic (Garcia et al., 2020). These findings suggest an increased need for interventions to improve health behaviors among adolescents with ASD in light of the COVID-19 pandemic.

Some parents in this study described the mental health impact of the COVID-19 pandemic, including increased anxiety related to COVID-19 exposure but also improved emotional regulation. Prior research has indicated that children with ASD have experienced increased anxiety and decreased emotion management due to the pandemic (Amorim et al., 2020). Prime and colleagues have suggested a conceptual framework to understand the differential impact of the COVID-19 pandemic on family well-being (2020). Further research is needed to examine differences in the impact of the COVID-19 pandemic on youth with ASD and their families, who may experience increased prevalence of anxiety (Schnabel et al., 2020; van Steensel et al., 2011). The impact of the COVID-19 pandemic on health behaviors among youth

with ASD should be considered by researchers and professionals who work with this population. Providers should be aware of the increased need for services and supports to improve the health and well-being of youth with ASD and their families.

## Conclusion

This study examined the feasibility, acceptability, and preliminary efficacy of BALANCE, a novel, theory-based virtual nutrition intervention for adolescents with ASD. As hypothesized, the virtual intervention was feasible for adolescents with ASD as measured by fidelity checklists and engagement records, and the Block Kids FFQ and psychosocial survey were practical to administer virtually to adolescents with ASD, as indicated by high response rate, completion, and data quality. An alternate version of the FFQ was completed by several participants who experienced technical barriers related to Adobe Flash. Also as hypothesized, the virtual intervention was acceptable for adolescents with ASD and their parents as measured by focus groups and interviews. Perceived benefits of the intervention included diet changes, healthy weight, knowledge/awareness, behavioral skills, self-efficacy, outcome expectations, outcome expectancies, and other lifestyle changes. Anxiety/discomfort during intervention lessons was reported as an unintended consequence. Post-intervention means were significantly greater than pre-intervention means for three of the seven hypothesized determinants: behavioral strategies, self-efficacy, and outcome expectations. It was hypothesized that there would be a trend toward significance for dietary intake and anthropometric measures; there was no trend toward significance for fruit and vegetable intake, but mean added sugar intake, total energy intake, BMI percentile, and BMI z-score significantly improved from pre- to post-intervention.

Findings from this study suggest that a virtual implementation of the BALANCE intervention may be effective at improving psychosocial determinants of dietary intake. Future

research on the BALANCE intervention should integrate self-determination theory, tailor the intervention for more specific age groups, and measure long-term outcomes compared to a control group. The findings also indicate that certain features should be considered for inclusion in future virtual interventions for adolescents with ASD, such as interaction, sensory activities, and reinforcing components. Lastly, further research is needed to adequately address external factors related to dietary intake in adolescents with ASD, including the food environment and family support, while considering the impact of the COVID-19 pandemic on youth and their families.

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