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Pilot Study of a Virtual Nutrition Intervention for Adolescents and Young Adults With Autism Spectrum Disorder

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Abstract

Objective: Examine the impact of a virtual nutrition education program, *Bringing Adolescent Learners with Autism Nutrition and Culinary Education* (BALANCE), on dietary intake and psychosocial determinants of healthy eating in adolescents and young adults (AYA) with autism spectrum disorder (ASD).

Methods: A sample of AYA with ASD aged 12–21 years (n = 27; 6 groups of 2–7 adolescents) participated in BALANCE, a Social Cognitive Theory-based intervention, for eight 30–45-minute lessons. Outcomes were compared using a pre-post design and included dietary intake (assessed using a food frequency questionnaire) and psychosocial determinants of healthy eating (assessed by a validated survey). Wilcoxon signed-rank tests compared preintervention and postintervention medians with an alpha level of 0.05.

Results: Mean added sugar intake ($P = 0.026$) decreased, and behavioral strategies ($P = 0.010$), self-efficacy ($P < 0.001$), and outcome expectations ($P = 0.009$) improved. There was no difference in fruit or vegetable intake or other psychosocial determinants.

Conclusions and Implications: The BALANCE intervention may improve psychosocial determinants and dietary behaviors in AYA with ASD. Future virtual programs may incorporate more assistance and support to be accessible for AYA with ASD of varying severity levels.

Keywords

nutrition; adolescents; autism; eHealth; Social Cognitive Theory

INTRODUCTION

Autism spectrum disorder (ASD) is a developmental disability characterized by 2 symptom domains: social communication challenges related to social-emotional reciprocity,

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nonverbal communicative behaviors, and developing relationships; and restricted, repetitive behaviors, including repetitive motor movements, highly restricted interests, hyperactivity or hyporeactivity to sensory input, and rigidity regarding routines and rituals.[1] Children with ASD are more likely than their typically developing peers to exhibit unhealthy eating behaviors, including food selectivity or consumption of a narrow range of foods,[2] and may consume more energy-dense foods and fewer fruits and vegetables.[3] These behaviors may continue into adolescence or adulthood, contributing to imbalanced nutrient and food group intake and an increased risk of unhealthy body weight and related health outcomes.[4]

Youth with ASD are more likely than youth without ASD to be overweight or develop obesity,[5] and there is evidence that odds of obesity increases with age in youth with ASD aged 10–17 years.[6] At the same time, youth with ASD have an increased likelihood of being underweight that increases into adulthood.[7,8] Research on long-term health outcomes of unhealthy body weight in individuals with ASD is lacking, but individuals without ASD tend to have a higher prevalence of diet-related chronic diseases such as dyslipidemia, type 2 diabetes, and cardiovascular diseases.[9–11] Generally, children with obesity are more likely to have obesity as adults and be diagnosed with chronic diseases such as type 2 diabetes, cardiovascular disease, and cancer.[12] Dealing with such outcomes may be especially burdensome for individuals with ASD who already experience high costs of education and medical and alternative therapies.[13]

Existing nutrition interventions for youth with ASD mostly aim to improve feeding difficulties, such as food selectivity, rather than promote healthy eating habits.[14–19] In addition, many of these studies have been conducted in children aged ≤8 years.[15–19] A few existing nutrition interventions that address healthy eating behaviors targeted only a small number of adolescents with ASD and included adolescents with other developmental disabilities in their samples as well, and therefore may not address ASD-specific issues, such as cognitive/behavioral rigidity and sensory differences.[20–24] Only 2 recent feasibility studies of nutrition education interventions have been conducted in samples of youth with ASD that included adolescents.[25,26]

To maximize the effectiveness of changing dietary behaviors of adolescents and young adults (AYA) with ASD, interventions may address ASD-specific issues and theory-based behavioral change mediators that are frequently targeted in nutrition education interventions. Although Social Cognitive Theory (SCT)[27] is often used in nutrition interventions to target psychosocial determinants of dietary intake,[28] existing interventions for AYA with ASD do not address psychosocial factors, such as self-efficacy and behavioral skills. Social Cognitive Theory assumes dynamic interaction between person, behavior, and environment (ie, reciprocal determinism).[29,30] Finally, as online nutrition education interventions show promise for improving dietary behaviors in youth without ASD,[31,32] there is a need for similar interventions to improve long-term healthy eating behaviors in AYA with ASD.

The purpose of this pilot study was to determine the efficacy of Bringing Adolescent Learners with Autism Nutrition and Culinary Education (BALANCE), an SCT-based nutrition intervention virtually implemented for AYA with ASD. The objectives were to examine whether dietary intake and psychosocial determinants of healthy eating changed from preintervention to postintervention. Exploratory outcomes included physical activity and sedentary behaviors.

METHODS

A 1-group pretest-posttest study design was used. The BALANCE intervention consisted of 8 weekly synchronous lessons delivered via Microsoft Teams (Microsoft Corporation, version 4.5.37, 2020). There were 6 groups of AYA with ASD who participated in the intervention (group size ranged from 2 to 7) between August and December, 2020. The 8-week intervention consisted of weekly 45-minute lessons, homework assignments, parent email handouts, and 3 parent webinars. During intervention lessons, participants could see and talk to each other and the lesson instructor. Participants were asked to avoid distractions and allow no one else in the room unless assistance was required. 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. Preintervention assessments were completed the week before the intervention, and postassessments were completed 1 week later. Quantitative methods were used to examine the efficacy of the BALANCE intervention.

Sample and Recruitment

Participants were recruited through a partnership with the Center for Autism and Related Disabilities at the University of South Florida (CARD-USF) and communications with other Center for Autism and Related Disabilities sites throughout Florida. Based on formative research, the target sample size was 30 AYA for a minimum of 3 groups so that group size would not exceed 10, which is consistent with references on pilot test sample size.[33–35] A recruitment flyer was distributed through the Center for Autism and Related Disabilities's listserv and shared on the Center for Autism and Related Disabilities at the University of South Florida's Facebook (Meta Platforms, Inc) page and ASD-related Facebook pages. Inclusion criteria for AYA included a parent-reported clinical diagnosis of ASD and a subject aged 12–21 years. Exclusion criteria were concurrent participation in another nutrition-related intervention, below third-grade reading level per parent report, eating disorder or feeding disorder diagnosis per parent report, or non-English speaking. The study was approved by the University of South Florida Institutional Review Board. Informed parent consent or adolescent assent was verbally obtained from all participants as approved by the Institutional Review Board. All participants received a $25 gift card as compensation for participating in the study.

Intervention

The BALANCE intervention included 8 weekly 30–45-minute lessons: exploring taste, flavor, and texture; mealtimes and rules; food groups and nutrients; moderation; beverages; cooking; well-being; and sustaining healthy eating habits. Formative research with children and AYA with ASD aged 8–19 years indicated that the BALANCE intervention content is age-appropriate for AYA with ASD aged 12 years and older.[36] The theoretical framework for BALANCE[37] consisted of SCT constructs and ASD-specific challenges, including sensory differences[38] and cognitive rigidity,[39] to promote dietary behavior change. Lesson activities were aligned with SCT constructs, including self-efficacy, behavioral skills, and outcome expectations. For example, SCT constructs of observational learning and behavioral skills were addressed in the lesson 5 activity, in which participants guessed the sugar content of various beverages and practiced finding the sugar content on a nutrition label. The BALANCE lesson activities and their alignment with SCT constructs are depicted in Table 1.

Measures and Data Collection Procedures

Data were collected at 2 time points: preintervention (baseline) and postintervention (9 weeks from baseline). Main outcomes of dietary behaviors and SCT-based psychosocial determinants were used to evaluate the effectiveness of the BALANCE intervention. At preintervention and postintervention, participants completed an SCT-based survey, the Block Kids 2004 food frequency questionnaire (FFQ)[40] and physical activity screener (PAS),[41] and virtual height and weight measurements. Food Frequency Questionnaire 1-month test-retest reliability (intraclass correlation coefficients [ICCs]) > 0.30 except for protein, fruit, and vegetables) and construct validity compared with 24-hour recall (adjusted correlation coefficient ranged −0.41 for grains to 0.83 for energy from carbohydrates for adolescents > 12 years, with better validity for nutrients than food groups)[40] and PAS construct validity compared with accelerometer (ICC, 0.30)[41] have been determined in typically developing adolescents. Because the psychosocial survey and FFQ had previously been piloted in a sample of 10 children and AYA with ASD aged 8–19 years and the instruments were feasible for AYA with high social communication skills or aged ≥ 15 years on the basis of acceptable response rate, completion, and data quality,[36] parents were told that they could help or complete surveys and questionnaires on behalf of their children if assistance was needed. Parents were asked to report via email whether their children required parent assistance to answer any questions. Demographics, ASD symptoms/behaviors, and height and weight were measured to determine sample characteristics.

A 37-item SCT-based survey developed and evaluated by Dewar et al[42] for adolescents (mean age, 13.7 years) was used to assess social cognitive measures related to healthy eating in adolescents. The initial validation study found acceptable-to-good internal consistency reliability (α = 0.65–0.79) and excellent factorial validity (ICC = 0.81–0.89).[42] Our analysis indicated that internal consistency was acceptable to good for each scale at preintervention (α = 0.62–0.84) and postintervention (α = 0.67–0.92). For all questions on the survey, a higher score is a better score. The response options and range of scores for each scale are noted in a footnote for Table 2. Median scores were generated for each scale on the survey. An online survey platform, Qualtrics (Qualtrics, 2002), was used to distribute the survey. The survey link was emailed to parents for their children to complete.

The Block Kids FFQ and PAS assessed dietary intake, physical activity, and sedentary behavior. The Block Kids Food FFQ is a 77-item questionnaire that asks participants about the consumption of various foods over the past week. The foods noted on the questionnaire are based on National Health and Nutrition Examination Survey 1999–2002 dietary recall data, and the nutrient database was developed based on the USDA Nutrient Database for Dietary Studies, version 1.0.[43] Because of the study being conducted in Florida where there is a large Hispanic/Latino population, NutritionQuest supplied a version of the Block Kids FFQ that asks about 7 culturally unique foods in addition to the typical list of foods. Participants were asked to complete the Block Kids FFQ through NutritionQuest's Data-on-Demand electronic system (NutritionQuest, 2021). In cases in which participants had difficulty accessing the NutritionQuest survey because of the Adobe Flash (Adobe Inc) requirement, 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. Eight parents reported that they helped their children clarify questions or recall food items consumed (eg, "I helped him remember milk and bread").

The Block Kids PAS (Nutrition-Quest) was combined with the Block Kids FFQ by NutritionQuest so that participants could log in and complete the PAS after completing the FFQ. The PAS was administered to participants with the FFQ preintervention and postintervention to collect data on physical activity and screen time as exploratory outcomes. The PAS asks about frequency and duration of activities in the past 7 days, with 9 items on minutes of leisure and school activities, chores, and part-time jobs and 1 item on hours of screen time (ie, television, video games, and internet) per day.

Dietary intake, physical activity, and screen time variables were coded and quantitated by NutritionQuest. Energy intake (kcal) and the following food group variables were used for the dietary intake analysis: added sugar (tsp equivalents per day), total fruit (cups per day), and total vegetables (cups/d). Physical activity variables included moderate activity (min/d), vigorous activity (min/d), and recreational activity (min/d). Energy intake was converted to kcal/kg because of the sample age range. The screen time question asks about hours of screen time per day and includes the following scale: 0, < 1, 1, 2, 3, ≥ 4 h/d.

A digital bathroom scale (Letsfit EB5636H, Letsfit) and a height-measuring ruler were purchased and shipped to each participant. Parents were asked to measure their children with ASD following procedures on the basis of the Centers for Disease Control and Prevention Guide to Measuring Children's Height and Weight Accurately at Home.[44] Virtual height and weight appointments were scheduled for parent-adolescent dyads via Microsoft Teams (Microsoft Corporation, version 4.5.37, 2020). 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 each. Body mass index was calculated on the basis of the Centers for Disease Control and Prevention growth charts, and body mass index z-scores were calculated following the Lambda Mu and Sigma method.[45]

A parent of each adolescent participant completed a demographic questionnaire at screening, with questions on child's age, gender, race/ethnicity, school type, co-occurring diagnoses, 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, and household income, as well as parent's age, gender, race/ethnicity, marital status, and education level. Gender was reported by parents from a list including male, female, nonbinary, and decline to answer. Race or ethnicity was reported by the parents from a list including Hispanic or Latino, American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or other Pacific Islander, White, and other (specify). Only one option could be selected.

Parents also completed an electronic version of the Autism Behavior Inventory—Short Form via Qualtrics at screening to examine AYAs' ASD symptoms and behaviors.[46] The Autism Behavior Inventory was developed as a parent-report scale to assess ASD symptoms and related behaviors of individuals aged 3 years to adulthood with sensitivity to short-term (7-day) change. The Autism Behavior Inventory—Short Form has the following domains: language level (1 question scored 1–5), social communication quality (3 questions scored 1–4), social communication frequency (3 questions scored 1–4), restrictive behavior frequency (7 questions scored 1–4), mood and anxiety frequency (5 questions scored 1–4), self-regulation frequency (3 questions scored 1–4), challenging behavior frequency (3 questions scored 1–4). Scale consistency for each domain, 3–5-day test-retest reliability (ICC = 0.77–0.88), and construct validity (correlation coefficients for each domain compared with the full ABI = 0.84–0.92) were determined in caregivers of individuals with confirmed diagnoses of ASD aged 6–54 years.[47] Questions were coded so that higher scores were better for language level and social communication, and lower scores were better for restrictive behaviors, mood and anxiety, self-regulation, and challenging behavior. Median scores were calculated for each scale.

Data Analysis

Univariate procedures including frequency distributions and descriptive statistics were performed for all measured variables. Wilcoxon signed-ranked tests were conducted to determine whether dietary intake (added sugar intake, fruit and vegetable intake, and total energy intake [kcal/kg]) and SCT constructs (self-efficacy, intentions, situation, social support, behavioral strategies, outcome expectations, and outcome expectancies) changed from baseline to postintervention. Exploratory analysis of physical activity and screen time was also performed with Wilcoxon signed-ranked tests. All analyses were performed in SPSS (version 24.0, IBM Corp, 2016) with an alpha level of 0.05. Shapiro–Wilk tests indicated that data were not normally distributed. To calculate sample size for a future randomized controlled trial, effect size ($r_{equivalent}$) was calculated using Rosenthal's formula[48] to compute correlations for nonparametric tests using added sugar intake as the primary behavioral outcome.[49]

To examine data quality, data were reviewed for response patterns[50] and inconsistent or unrealistic answers. One FFQ was excluded for straight-lining (choosing the same option for every item), and no inconsistent or unrealistic answers were detected. Two FFQs were excluded because of reported energy intake < 500 kcals/d.[51] 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. Missing data were handled with pairwise deletion. Data were assumed to be missing at random because the amount of missing data was so low (4% of administered surveys and 0.4% of completed surveys).

RESULTS

Of the 34 parents interested in the study, 31 adolescent-parent dyads completed eligibility screening and informed consent/assent. All participants who completed the screening were eligible to participate. Two participants did not respond to follow-up after completing ≥ 1 baseline measure, and 2 other participants dropped out after completing lesson 1 of the intervention. Parents of both participants who dropped out after lesson 1 reported their children's challenging behaviors during the lesson as a reason for dropping out. One parent also reported her work and school-related stress as a reason. Results are presented for the 27 AYA who completed the intervention (sample ranged from 21 to 26 for outcome variables).

Of those who completed the intervention, 74% were male, and the median age was 15 years (range, 12–20 years) (Table 2). Participants'race/ethnicity was 63% White, 15% Hispanic, 7% Black or African American, 4% Asian, and 11% Other (Asian and White). The baseline prevalence of overweight and obesity was 31%, and the baseline prevalence of underweight was 8%. At postintervention, 1 participant had improved from obesity to overweight, 1 participant improved from overweight to healthy weight, and 1 participant improved from underweight to healthy weight. Most participants were either homeschooled (44%) or attended public school (26%). The most commonly reported diagnoses were attention-deficit hyperactivity disorder (78%) and sensory processing disorder (41%). 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. Nearly half of participants (48%) came from households with reported income of ≥ $75,000. All parents who completed the demographic questionnaire were female, and the majority of parents identified as White (70%) and reported a bachelor's degree or higher as their highest level of education (67%).

Daily intake of total energy (kcal/kg), added sugar, total fruit, and total vegetables were compared from preintervention to postintervention (Table 3). The postintervention median for added sugar intake ($P = 0.03$; $r_{equivalent} = 0.47$) was significantly lower than preintervention medians. Screen time significantly reduced from preintervention to postintervention ($P = 0.04$; $r_{equivalent} = 0.44$). Results for median comparisons were statistically significant ($P < 0.05$) for 3 of the 7 SCT constructs measured. Postintervention medians were significantly higher for behavioral strategies ($P = 0.01$; $r_{equivalent} = 0.50$), self-efficacy ($P < 0.001$; requivalent = 0.63), and outcome expectations ($P = 0.009$; $r_{equivalent}$ = 0.51).

DISCUSSION

The objective of this study was to examine the efficacy of the virtual BALANCE intervention by evaluating the preintervention and postintervention median differences in dietary intake, physical activity and sedentary behaviors, and psychosocial determinants of healthy eating. The feasibility of implementing the intervention and measurements has been evaluated and reported elsewhere.[37] In summary, process data indicated that the BALANCE intervention was feasible to be implemented virtually with a group of AYA with ASD, with a high response rate (93% to 100%), completion (99% to 100%), and data quality

(88% to 100% of surveys completed had high quality (ie, no inconsistencies or unrealistic responses)).

The postintervention median for added sugar intake ($P = 0.03$) was significantly reduced, whereas there was no significant difference between preintervention and postintervention medians for energy intake (kcal/kg) or total fruit or total vegetable intake, despite fruit and vegetables being discussed in nearly all lessons. Using added sugar intake as the primary behavioral outcome, this study yielded an effect size of $r_{equivalent} = 0.47$. 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. Although fruit and/or vegetables were discussed in 7 out of 8 BALANCE lessons, texture and taste issues may be ongoing barriers to significantly improving fruit and vegetable intake that require longer-term intervention. Changes in physical activity and sedentary behavior were not expected as there was no physical activity component to the BALANCE intervention.

Postintervention medians were significantly improved for behavioral strategies ($P = 0.01$), self-efficacy ($P < 0.001$), and outcome expectations ($P = 0.009$). There is a lack of nutrition interventions that measure SCT constructs in youth with ASD. A previous, 24-lesson SCT-based nutrition intervention for youth aged 12–13 years without ASD found increased outcome expectations and self-efficacy and increased goal intentions, competence, and autonomy.[52] A virtual 8-week SCT-informed nutrition intervention for youth aged 12–15 years without ASD has reported increased knowledge about physical activity and nutrition (effect size = 0.18, $P = 0.001$).[53]

Strengths of the study include using a novel, theory-based nutrition intervention developed for AYA with ASD. *Bringing Adolescent Learners with Autism Nutrition and Culinary Education* was designed on the basis of 2 years of preliminary research, aided by perspectives and feedback from AYA with ASD and their parents and teachers, and evidence-based strategies for individuals with ASD,[54,55] SCT-based activities,[56] and youth nutrition education activities.[57] The application of health behavior theory, such as SCT, has been reported as a factor contributing to successful online nutrition education interventions.[31,58]

Despite the strengths of the study, there are several limitations to consider. As this was a pilot study, there was neither a control group nor an in-person intervention group to compare differences in preintervention and postintervention medians. Because of the study design and small sample size, this study has low generalizability and potential for bias. As this was a pilot study, the main objective goal was to establish the impact of the intervention and estimate the effect size to base power analysis for a larger scale efficacy study in the future. Test-retest reliability of instruments was not examined, and the scales used to measure body weight do not have published validity or reliability information. In addition, because of the instruments used for the study, there is potential for self-report bias, recall bias, and social desirability bias. The validity and reliability of the Block Kids FFQ and psychosocial survey is unknown in AYA with ASD, as these instruments were developed for adolescents without ASD. The analyses were not corrected for baseline. Using an FFQ instead of a 3-day 24-hour recall is a further limitation. Moreover, the FFQ used in this study has low reliability for fruit and vegetable intake and a lack of reliability and validity data for added sugar. However, the feasibility of conducting dietary recalls and food records was low in our previous pilot study with a sample of adolescents with ASD, and the FFQ was feasible to administer.

IMPLICATIONS FOR RESEARCH AND PRACTICE

The theoretical framework of the current study, informed by SCT, helped identify potential target areas for future interventions, including behavioral strategies, self-efficacy, and outcome expectations–SCT constructs that were significantly improved at postintervention in our study. Activities from the BALANCE intervention that may be applicable for researchers and practitioners to target these determinants of dietary intake include teaching AYA with ASD how to make healthy snacks (lesson 2), fostering confidence related to healthy eating by discussing ways to overcome environmental challenges (lesson 7), and describing the role of healthy eating in accomplishing personal goals (lesson 3). However, as autism is a spectrum disorder, what works for 1 AYA with ASD may not work for another AYA with ASD, or there may be day-to-day variability regarding effectiveness for 1 AYA with ASD. In addition, the participants in this study required minimal support, and 2 participants who required more substantial support dropped out after lesson 1. Future virtual programs may incorporate more assistance and support to be accessible for AYA with ASD of varying severity levels. If further research on BALANCE confirms that the intervention effectively improves healthy eating behaviors and their determinants, BALANCE may be disseminated into practice via virtual settings.

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Table 1.

Application of SCT Constructs to Lesson Activities for BALANCE, the 8-wk Virtual Nutrition Education Program for Young People With Autism Spectrum Disorder

Minutes	Activities	Constructs
Lesson 1: exploring taste, flavor, and texture		
5	Engage students in an interactive discussion of taste, flavor, and texture	Knowledge, self-efficacy
30	Conduct 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		
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		
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 US Department of Agriculture's MyPlate	Knowledge, self-efficacy, observational learning
10	Discuss snacks and their food groups and benefits	Knowledge, outcome expectations
Lesson 4: moderation		
5	Review the lessons conducted 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		
10	Engage students in an interactive discussion on beverages	Knowledge
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		
10	Discuss current practices for preparing food at home	Self-efficacy, social support

Minutes	Activities	Constructs
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		
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		
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

BALANCE indicates *Bringing Adolescent Learners with Autism Nutrition and Culinary Education;* SCT, Social Cognitive Theory.

Table 2.

Preintervention and Postintervention Medians for Dietary Intake (n = 22), Screen Time (n = 22) and Physical Activity (n = 21), and Psychosocial Determinants of Dietary Intake (n = 26) Among Adolescents and Young Adults With Autism Spectrum Disorder Who Participated in the Virtual 8-wk BALANCE Virtual Nutrition Education Program

Characteristics	Baseline Median (IQR)	Postintervention Median (IQR[a])	*P* [a]
Dietary intake			
Energy (kcal/kg)	25.4 (20.6–38.6)	24.8 (16.8–35.6)	0.05
Added sugar (tsp equivalents)	10.1 (7.9–15.2)	8.1 (6.3–10.8)	0.03 *
Total fruit (cups)	1.5 (0.4–2.7)	1.0 (0.5–2.3)	0.211
Total vegetables (cups)	0.9 (0.6–1.4)	1.0 (0.6–1.3)	0.615
Screen time and physical activity			
Screen time (1–6)[e]	6.0 (6.0–6.0)	5.5 (4.0–6.0)	0.04 *
Moderate activity (min/d)	12.6 (2.4–37.9)	19.8 (8.4–39.3)	0.27
Vigorous activity (min/d)	0.0 (0.0–11.9)	2.1 (0.0–9.1)	0.393
Recreational activity (min/d)	8.4 (0.0–27.3)	8.4 (2.1–18.1)	0.931
Psychosocial determinants of dietary intake			
Behavioral strategies[b] (1–5)	2.7 (2.3–3.0)	3.1 (2.8–3.5)	0.01 *
Situation[c] (1–6)	5.8 (5.0–6.0)	5.8 (4.9–6.0)	0.407
Social support[b] (1–5)	4.2 (3.6–4.6)	4.1 (3.7–4.5)	0.372
Self–efficacy[c] (1–6)	3.0 (2.6–4.0)	4.0 (3.1–4.5)	0.001 ***
Outcome expectations[c] (1–6) (n = 25)	4.9 (4.4–5.5)	5.8 (4.8–6.0)	0.009 **
Outcome expectancies[c] (1–6)	3.2 (3.0–4.0)	3.2 (3.0–3.8)	0.935
Intentions[e] (1–4)	2.8 (2.2–3.2)	2.9 (2.6–3.5)	0.08

BALANCE indicates Bringing Adolescent Learners with Autism Nutrition and Culinary Education; IQR, interquartile range.

[a]Wilcoxon signed-rank tests were conducted to compare baseline and postintervention medians for all variables listed;

[b]Response options: Never, rarely, sometimes, often, or always;

[c]Response options: Strongly disagree, disagree, disagree slightly, agree slightly, agree, or strongly agree

[d]Response options: Not at all true of me, not very true of me, somewhat true of me, or very true of me;

[e]Response options: 0, < 1, 1, 2, 3, ≥ 4 h/d.

*$P < 0.05$;

**$P < 0.01$;

***$P < 0.001$.

Table 3.

Baseline Demographic Characteristics for Young People Who Participated in the 8-wk BALANCE Virtual Nutrition Education Program (n = 27) and Their Parents

Characteristics	Description, n (%)
Age, y[a]	15.0 (13.0–16.0)
Gender	
Male	20 (74)
Female	7 (26)
Race/ethnicity	
Hispanic or Latino	4 (15)
Asian	1 (4)
Black or African American	2 (7)
White	17 (63)
Other	3 (11)
Baseline BMI category	
Obesity	5 (19)
Overweight	3 (12)
Healthy weight	16 (62)
Underweight	2 (8)
Baseline BMI z-score[a]	
BMI z-score	0.07 (−0.5 to 1.4)
Symptoms of autism spectrum disorder[a,b]	
Language level[c] (1–5)	5.0 (0.2)
Social communication: quality[d] (1–4)	3.3 (3.0, 3.7)
Social communication: frequency[e] (1–4)	2.7 (2.3, 3.3)
Restrictive behaviors: frequency[e] (1–4)	2.0 (1.7, 2.6)
Mood and anxiety: frequency[e] (1–4)	2.6 (2.0, 3.0)
Self-regulation: frequency[e] (1–4)	2.0 (1.7, 2.7)
Challenging behavior: frequency[e] (1–4)	2.0 (1.0, 2.3)
School type	
Public	7 (26)
Private	3 (11)
Homeschool	12 (44)
Other	4 (15)
Graduated	1 (4)
Other diagnoses	
Sensory processing disorder	11 (41)
Attention-deficit hyperactivity disorder	21 (78)
Obsessive compulsive disorder	2 (7)

Characteristics	Description, n (%)
Sleep disorder	6 (22)
Other[f]	15 (56)
Food allergies or intolerances	
Yes	10 (37)
No	17 (63)
Hours of sleep per night[a]	8.5 (8.0, 9.0)
No. of children in household[a]	2 (1,3)
No. of individuals in household[a]	4 (3, 5)
Household income	
< $20,000	2 (7)
$20,000–$34,999	1 (4)
$35,000–$49,999	3 (11)
$50,000–$74,999	8 (30)
$75,000–$99,999	4 (15)
> $100,000	9 (33)
Parent age[a]	48.5 (46.0,54.0)
Parent gender	
Female	27 (100)
Parent race/ethnicity	
Hispanic or Latino	4 (15)
Black or African American	2 (7)
White	19 (70)
Other	1 (4)
No response	1 (4)
Parent marital status	
Married	20 (74)
Widowed	1 (4)
Divorced or separated	6 (22)
Parent highest education completed	
Some college	4 (15)
Associate’s degree	5 (19)
Bachelor’s degree	7 (26)
Graduate degree	10 (37)
Other	1 (4)

BALANCE indicates Bringing Adolescent Learners with Autism Nutrition and Culinary Education; BMI, body mass index.

[a]Results represent median and interquartile range;

[b]Based on responses from the Autism Behavior Inventory–Short Form;

[c]Response options: no language, signs, single words or 2–3 word utterances, simple sentences, or full sentences;

[d]Response options: not at all, with support, with some reminders, or without help;

[e]Response options: never, sometimes, often, or very often;

[f]Responses included: anxiety, auditory processing disorder, learning disabilities (dysgraphia, dyslexia, and nonverbal 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.