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Promoting physical activity participation and nutrition education through a telehealth intervention for children on the autism spectrum and their caregivers

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ABSTRACT

There is growing empirical support which suggests children on the autism spectrum, as well as their caregivers experience significant health disparities. The global COVID-19 pandemic has only magnified the need to address health among vulnerable populations. While there has been a growing trend in the delivery of telehealth interventions, the delivery of such methods for children on the autism spectrum, and their caregivers remains relatively under examined. The primary goal of PLANE (Physical Literacy And Nutrition Education) is to promote positive trajectories of health for children on the autism spectrum and their primary caregivers through the delivery of a telehealth physical activity and nutrition education program. The study is a pre-experimental analysis of PLANE across 12 months. All activities will be delivered virtually through weekly synchronous and asynchronous programming. A total of 180 participants will be enrolled in this intervention, including children on the autism spectrum and caregivers. Each week a new physical activity skill along with opportunities for recipe assembly will be delivered remotely. Supplemental material will be disseminated online including: step by step directions outlining behavioral skill methodology, opportunities for additional skill practice, and reading material that support weekly topics. Study outcomes will be examined in the parent-child dyad and include rates of overweight/obesity, physical activity, nutrition and quality of life. Finally, feasibility of the telehealth intervention will also be measured. Justification for the conceptualization and delivery of PLANE is well warranted, and PLANE represents a promising intervention which is scalable, sustainable, and replicable.

1. Introduction

When compared to their neurotypical peers, children on the autism spectrum are more likely to experience health disparities [1–5]. This is concerning given over the past two decades, rates of Autism Spectrum Disorder (ASD) have increased 150%, with revised estimates suggesting 1/54 children, aged 8 years in the United States, are diagnosed with the disorder [6]. While developmental deficits typically present in social engagement, evidence now suggests the presence of health disparities are pervasive, and include disproportionate differences in obesity when compared to neurotypical peers [5]. Engagement in 60 min per day of moderate to vigorous physical activity (MVPA) can promote a healthy weight status, however, children with ASD are more predisposed to an age-related rate of decline in activity levels [7]. Adding to the complexity of health disparities among children with ASD is the presence of feeding disorders. Between 70 and 90% of children with ASD experience extreme selectivity and sensory-related aversions to food tastes and textures, as well as difficulties in chewing and swallowing [8,9]. A key contributor to the presence of health disparities in children on the autism spectrum are the well-documented lack of accessible health, physical activity, and nutrition programs [10,11]. The global COVID-19 pandemic has only magnified the need to address health disparities among vulnerable populations including children on the autism spectrum. While there has been a growing trend in the telehealth delivery of health interventions, the delivery of such methods for individuals on the autism spectrum, as well as their caregivers, is relatively under examined. Health interventions, particularly those with potential for translation, are an area of need for children with developmental disabilities [12].

Telehealth interventions to improve outcomes among children on
the autism spectrum have proven efficacious, including positive behavioral improvements [13] and improved communication [14]. Despite the noted health disparities among children on the autism spectrum, there are a scarcity of telehealth interventions which improve physical health in this population. A recently published study examined the feasibility of a 12-week long exercise intervention for youth on the autism spectrum delivered through a social media platform [15]. While outcomes suggest parents were ‘satisfied’ or ‘very satisfied’ with the intervention, a significant increase in physical activity (PA) was not achieved [15]. Telehealth has been used effectively to provide outpatient feeding services for individuals with intellectual and developmental disabilities (IDD), including children on the autism spectrum [54,55]. Most notably, the program was effective in reducing parent costs related to time and travel [54]. These two factors are critical to any health intervention, especially among families with lower socioeconomic status. Next, while telenutrition has been identified as an effective treatment intervention to improve weight, body mass index (BMI) and blood pressure in the general population [16], additional implementation outcomes need to be examined for children on the autism spectrum given many experience extreme sensitivity regarding food preferences [17].

The majority of research examining the effectiveness of health promotion programs have focused on school-aged children, with very little consideration regarding the health of parents raising a child with a disability. Unfortunately, parents who have a child with a disability are more at greater risk of physical and mental health disparities when compared to the general population [8,18-20]. A chronic level of parenting stress may have additional longitudinal implications on physical health [8,18]. While participation in physical activity is a known contributor to promoting positive trajectories of health, empirical research suggests parents of children with disabilities are less active when compared to parents of neurotypical children [21]. Despite these findings, empirically supported interventions promoting physical activity for this population are scarce.

1.1. Objectives

To simultaneously address the current need for telehealth programming, due to global pandemic, and to address the complexity of issues contributing to health disparities, a one-year telehealth program, Physical Literacy and Nutrition Education (PLANE), will be delivered to children on the autism spectrum, as well as their primary caregivers. Our first objective is improve weight status over the one-year period among children and caregivers. Our secondary objective is to improve the health behaviors in children on the autism spectrum as well as their caregivers (i.e., physical activity, nutrition practices). The third objective is to improve quality of life and reduce rates of depression and anxiety among caregivers. Our final objective is to determine the fidelity and feasibility of participation in a telehealth intervention for children on the autism spectrum and their caregivers.

2. Methods and materials

2.1. Overview of study design

A pre-experimental one-group, pre-post design will be utilized for the operation of PLANE. Given the relative void of telehealth programs promoting positive health outcomes for children on the autism spectrum and their families, the framework for this type of intervention needs to be proven efficacious. Given this design is operationalized to a single group only with consistent methods and measures, it will allow for adjustments whenever needed for population specific accommodations and modifications.

2.2. Theoretical model

The PLANE intervention is grounded in Social Cognitive Theory [22]. SCT is based on the idea that behaviors occur through dynamic and reciprocal interactions between the person, their behaviors, and their environments [22]. This theory has been used extensively to examine and explain health behaviors, including nutrition and PA [23]. Key constructs of SCT targeted in the PLANE intervention include goal setting (caregiver and child weekly PA goals), positive reinforcement (rewards for meeting goals), self-regulation (weekly PA tracking), social support (within participating PLANE family members), and behavioral capability (nutrition and PA educational materials). Self-efficacy, self-regulation, and motivation are all thought to be important factors in PA participation for children and adolescents with ASD [5,24-28]. Further, the theoretical model has been used effectively in promoting PA in children with ASD through parent-mediated intervention [15,29].

2.3. Participants

All study procedures will be approved by the local Institutional Review Board (IRB). Both written informed consent, and when appropriate, child assent will be solicited prior to study enrollment. Study recruitment will be conducted through a variety of online networks including applied behavioral analysis (ABA) clinics, local school systems, caregiver support networks, and service providers (e.g., physical and occupational therapists). To be included in this study, all children on the autism spectrum will be between 2 and 18 years of age, have a confirmed diagnosis of autism spectrum (from medical provider or school service provider), and live within the urban city limits where the intervention and research staff are affiliated. Overweight or obese weight-status is not an inclusion or exclusion criteria for the study, although we do expect to recruit families of overweight children based on our previous studies in this community [30]. While PA and nutrition education programming will be delivered virtually, to participate in PLANE, parents must be able to participate in an initial equipment and supplies pick up/drop off, as well as a weekly grocery pick up/drop off. To qualify for initial and weekly drop offs, 24-h prior notice sent through email to the PLANE research staff will be required. Finally, caregivers should have access to a smart phone, ipad, tablet or computer as well as internet access. If internet access is temporarily suspended during the intervention, accommodations can be made for continuous participation through the use of community ‘wifi’ hotspots. When interested, more than one caregiver is allowed to enroll into the intervention.

The principal investigator (PI) of the intervention will be a certified adapted physical education teacher with over 15 years of delivering community based PA and health programming, along with doctoral credentials in the field of adapted physical activity. The PI of the intervention will oversee all PLANE operations including program recruitment, enrollment, weekly program delivery, family adherence, incentive dissemination and data collection administration. To spearhead the delivery of PA and nutrition education programming 3 staff with board certified behavioral analyst (BCBA) qualifications will be hired as coaches. To build rapport and to keep within best practices for instructional delivery for children on the autism spectrum [31], each coach will be hired to work with the same age group (e.g., ages 2–5, 6–12, or 13–18) throughout the duration of the intervention.

2.4. Intervention components

Upon enrollment, all families will pick up an assortment of PA equipment and nutrition education supplies. The PA equipment will include items for both caregiver and child intervention participation. Child equipment will include items that facilitate age and developmentally appropriate PA participation including tennis balls, basketball, volleyball, baseball tee, hockey stick, bat, jump rope and hula hoops. Caregiver equipment will include equipment commonly used in a...
recreational fitness center including exercise bands, weighted bars, dumbbells, sliding disks (meant for frictionless abdominal workouts) kettle ball (weighted ball with handle), agility ladder, a yoga ball, and mat. Additionally, families will be given a scale along with a wall-mounted measuring tape for objective measures of height and weight. Next, all family members who enroll in PLANE will receive a MovBand 5, a small wrist accelerometer about the size of a watch to measure daily PA levels. The nutrition education supplies will include all kitchen utensils and tools required to assemble healthy food recipes. For example, to facilitate ingredient assembly aligned with the Dietary Guidelines for American [32] families will receive an assortment of additional orientation will be hosted where intervention details will be shared with each family. Families can keep a record of activities by simply checking the boxes of when weekly PLANE components have been met.

2.5. Intervention implementation

This longitudinal intervention will be delivered for 52 weeks (one year). Given the health disparities that may already be evident in both child and caregiver, a longer intervention is warranted to observe significant changes. Additionally, previous intervention research promoting positive health outcomes for children on the autism spectrum recommend a longitudinal design [30,31]. Both PA and nutrition intervention content will incrementally build throughout the year long intervention, scaffolding each week on previous concepts. This technique, commonly referred to as ‘spiral teaching’ [33] will begin each session with a review of previously acquired skills or knowledge, followed by the introduction of the new content. In this way, it is anticipated that children and parents will increase their skill development throughout the intervention, continually practicing and refining their new patterns of behaviors overtime.

Given the scope of the PLANE, a number of strategies meant to promote program adherence and participation retention have been embedded throughout the intervention. During the recruitment process, all PLANE components will be thoroughly described to caregivers, providing a realistic overview of the comprehensive nature of the intervention. If caregivers remain interested and wish to enroll, an additional orientation will be hosted where intervention details will be reviewed in greater detail. Another retention strategy includes the consistency of staff that will be retained throughout the intervention. Lead coaches will remain with their assigned age groups throughout duration of the intervention. In this way, coaches and families will continue to build a rapport with one another that is anticipated to strengthen throughout the year. In addition to a weekly email containing pertinent information regarding synchronous Zoom links and asynchronous website resources, all parents will also be subscribed to a texting app. The texting app allows the research assistants to remind parents of weekly grocery pick-ups. Finally, to keep track of intervention components, a laminated and magnetized calendar with all requirements is shared with each family. Families can keep a record of activities by simply checking the boxes of when weekly PLANE components have been met.

2.6. Child synchronous - physical activity class

For children ages 2–5, physical activities will focus on the development of fundamental motor skills (e.g., throw and catch). Instruction on these skills will serve as building blocks for future safe and enjoyable PA participation. For children ages 6–12, the focus will be on sports sampling (e.g., yoga, and team sports). For youth ages 13–18, physical activities will focus on skills including building strength and cardiovascular fitness, home-based fitness programs, and preparing youth for fitness center usage. Given the diversity of research participants proposed, opportunities to engage in PA will be varied and include multiple forms of representation. First, for children on the autism spectrum, each of the three age groups will be meet once weekly for 60 min with their lead coach in small group settings. A consistent telehealth routine will be operationalized each week, including: 1) movement to songs, 2) a social greeting, 3) an overview of the ‘skill of the week’ with key words for practice, 4) opportunity for practice and reinforcement, 5) a review of different online resources available to practice the skill, 6) closing with yoga and breathing exercises, and 7) discussion with caregivers about their upcoming goals for the week. Facilitating questions will be asked throughout the session to elicit both verbal (e.g., yes, or no) and non-verbal (e.g., thumb ups, head nod) responses. While efforts to create age and developmentally appropriate activities will be taken, a fidelity checklist will be administered by a research assistant to ensure consistency of routine within and between sessions in each age group (see Table 2). Evaluation for fidelity will be administered based only on the recorded live synchronous Zoom sessions. All PA lessons will be delivered by BCBA’s with prior experience delivery PA programming.
Table 2
Child zoom fidelity checklist.

| Item                                      | Completed(Y/N) | Notes |
|-------------------------------------------|----------------|-------|
| Movement to dance                         |                |       |
| Social greeting                           |                |       |
| Target skill named with key words         |                |       |
| Target skill practice (without equipment) |                |       |
| Practice skill (without equipment)        |                |       |
| Review opportunities additional skill practice (available on worksheet and PLANE website) | |       |
| Facilitating questions eliciting verbal or non-verbal response regarding skill of the week | |       |
| Yoga and breathing routine                |                |       |
| Completion of goal setting link with families |            |       |

Table 3
Asynchronous worksheet overview.

| Child Physical Activity | Worksheet Component | Additional Information |
|-------------------------|---------------------|------------------------|
| Overview of Lesson Content in Worksheet | PA Recommendations | Children and adolescents ages 6–17 should participate in 1 h or more of moderate to vigorous PA daily, and on 3 days per week activity should include vigorous PA. * |
|                         | Skill of the Week   | Example - Baseball |
|                         | Video               | PLANE curated video will be accessible through online worksheet and on YouTube channel, video will include: step by step directions on how to perform skill, key words, and an opportunity to practice skills (e.g., striking, running, sliding, throwing, catching) |
|                         | PA Equipment        | Equipment: Baseball tee, baseball bat, whiffle ball, cones |
|                         | Additional Skill Practice | Additional opportunities to online resources will be shared to continue to practice baseball skills for example: a read along book about a famous player, a trivia game to play with the family about baseball, or ways to modify the game to promote inclusion for all populations |
|                         | Learning Resource   | A learning resource about baseball will be shared, additional opportunities to participate in PA will be shared each week including: ideas for movement to music, yoga routines, and a game to play with the entire family |
|                         | Movement Ideas for Family | Additional opportunities for family to practice baseball skills will include: step by step directions on how to perform skill, key words, and an opportunity to practice skills (e.g., striking, running, sliding, throwing, catching) |
|                         | Caregiver Physical Activity | Overview of Lesson Content in Worksheet |
|                         | Worksheet Component | Additional Information |
|                         | PA Recommendations | Adults should do at least 150 min a week of moderate intensity, or 75 min a week of vigorous intensity aerobic PA. Additional recommendations include: Move more and sit less, complete PA throughout the week, do muscle strengthening activities at least 2 days/week |
|                         | Skill of the Week   | Example - High Intensity Interval Training (HIIT) |
|                         | Video               | PLANE curated video will be accessible through online worksheet and on YouTube channel, video will include: an introduction to HIIT workouts, a mini HIIT lesson, and conclude with a stretching, breathing and mindfulness routine |
|                         | PA equipment        | Equipment: Yoga mat, weighted bars, kettlebells, cones |
|                         | Additional Skill Practice | Additional opportunities to online resources will be shared to access other HIIT workouts |
|                         | Learning Resource   | A learning resource about PA will be shared, for example: a link to ideas for logging PA minutes, tips sheets on how to move more and sit less during the day, and information on how to make telehealth PA engagement easier |
|                         | Advocacy, Social Services and Self Care | Additional resources for caregiver investment and education will be shared each week including: educational advocacy information, social service workshops and ideas for self-care while caring for child with developmental disability |
|                         | Family Nutrition Education | Overview of Lesson Content in Worksheet |
|                         | Worksheet Component | Additional Information |
|                         | USDA Recommendations | What foods are in the fruit group? Any fruit of 100% fruit juice counts as part of the Fruit Group. Fruits may be fresh, canned, or dried and may be whole, cut-up, or pureed. |
|                         | Recipe of the Week  | How many fruits are needed? The amount of fruits you need to eat depends on your age, sex and level of physical activity. The amount each person needs can vary between 1 and 2 cups each day. |
|                         | Video               | Example – Dried Fruit |

*In the live Zoom session, the live recording will be sent to the caregiver for the opportunity to participate in activities asynchronously.

2.7. Child asynchronous - physical activity worksheets

To expand opportunities for PA participation, additional online resources will be available through a clickable pdf worksheet (see Table 3 and refer to appendix) each week. Worksheet content will include: 1) age group specific PA recommendations from the Physical Activity Guidelines (PAG; 2018), 2) a curated PLANE skill of the week video (prerecorded from PLANE research staff), 3) supplemental PA workouts (which reinforce the skill of the week), 4) activities to engage in PA as a family, and 5) online learning resources which facilitate the acquisition of knowledge regarding the importance of incorporating activity into daily routines. The learning material is related to the skill of the week in each age group, where families can continue to practice and refine their skills and behaviors with a variety of modalities. For example, if the middle school age group is working on yoga and mindfulness concepts, additional skill practice may be a found on the pdf worksheet and include an external link to an instructional video on how to embed ‘mindful minutes’ throughout the school day.

2.8. Adult synchronous - physical activity class

Workouts for adults will follow recommendations from the PA guidelines [34] for multicomponent PA, including lesson foci on strength training, yoga, high intensity interval training (HIIT) and cardiovascular workouts. Caregivers will meet once per week for 60 min with a lead coach who has credentials as a National Academy of Sports Medicine personal trainer. All telehealth sessions will include, 1) a warmup, 2) guided stretching routine, 3) participation in a multicomponent PA workout, and 4) conclude with a mindfulness and yoga cool down. Following the conclusion of the workout, a review of the weekly pdf will be administered in the final few minutes of the Zoom session. Similar to child PA lessons, evaluation for fidelity will be administered based on the recorded live synchronous Zoom sessions. For families who did not participate in the live Zoom session, the live recording will be sent to the caregiver for the opportunity to participate in activities asynchronously.

2.9. Adult asynchronous - physical activity worksheets

Additional PA programming for parents will be available asynchronously. Similar to the asynchronous programming for youth, their activities will be available online, and retrieved through a clickable pdf worksheet (see Table 3 and refer to appendix). Within each worksheet, tailored PLANE curated videos will be embedded with a focus on ways to achieve national PA recommendations. Additional skill practice on the theme of the weekly synchronous lesson will be recommended along with a link to external resources. Next, learning resources on the benefits to children on the autism spectrum. For families who did not participate in the live Zoom session, the live recording will be sent to the caregiver for the opportunity to participate in activities asynchronously.

(continued on next page)
of PA, tips on how to incorporate family PA, ways to achieve more daily PA and goal setting strategies will be shared.

2.10. Parent/child - asynchronous - nutrition education, parent/child dyad

In order to participate in the nutrition education lessons, caregivers will be required to travel to a consistent centralized geographic location for a contactless ingredient pick up each week. Distribution of the food will proceed the start of the lesson for the week. For families without transportation, groceries will be delivered to their home by a research assistant. To address many of the unique feeding disorders experienced by children on the autism spectrum, all nutrition education lessons will be pre-recorded by BCBAs who have extensive experience in the operationalization of behavioral interventions used to promote healthy eating behaviors. In this way, the nutrition education will be delivered asynchronously and include a variety of accommodations and modifications for children on the autism spectrum. For example, content could include suggestions for tastings with fewer ingredients, recommendations for an increase or decrease in textured options, and opportunities to allow the child to choose different ingredient combinations. All nutrition education lessons are based on US dietary guidelines and support healthy choices in the home environment including nutrition basics, healthy snack and meal habits, and food preparation. Lessons will follow a consistent routine that includes, 1) an overview of the recipe for the week, 2) step by step directions for recipe preparation including hand washing, 3) ingredient assembly, 4) instructions for how to use any kitchen tools (i.e., can opener, oven), and 4) conclude with an opportunity to sample the recipe as a family.

To supplement every nutrition education lesson, a number of additional online resources will be available through a clickable pdf worksheet. The worksheet will include a review of the USDA healthy eating guide, including recommendations for serving size, ideas for how to use any extra ingredients following recipe assembly, and nutrition education activities to complete as a family. See Table 3, and refer to appendix.

2.11. Incentives

To compensate caregivers for their time and increase adherence in completing the survey responses included in PLANE, a $40.00 amazon gift card will be distributed at each of the data collection time points. The distribution of the gift cards will be through email addresses. Next, families will be incentivized to participate in programming through a goal setting component of PLANE. As outlined in Table 2, families will spend the final few minutes of their synchronous PA sessions each week completing a short survey to make PA and nutrition goals for the child and caregiver. This time is meant to provide families with an opportunity for social support with their coaches and/or fellow research participants. In this way, family participants will work together each week to create an achievable physical activity goal. The goals are personalized to the activity needs of each family.

Progress on goals will be monitored by PLANE research staff; however, families can check the status of their progress through a remote access drive. Every family will be assigned a punch card that PLANE research staff will complete as families report reaching their goals. Incentives will include an option to select from additional sports equipment and nutrition supplies. To qualify for the incentive, families must meet their goal three out of four weeks, incentives will be distributed one time per month at the end of each month. While the opportunity to work towards an incentive is ‘re-set’ at the beginning of each month, a cumulative goal adherence throughout the year is also monitored and rewarded (see Table 4).

2.12. Outcomes

The majority of measures noted below will be solicited at 3 time points, including, A) 1-week pre intervention, B) midway at 6 months, and C) at 1-week post intervention. In addition to the four defined time points, data will be collected weekly on PA behaviors and intervention adherence throughout the program. See Table 5 for a timeline of outcome evaluations.

2.13. First objective: weight status

To measure improvements in rates of obesity/overweight in children and their families, we will evaluate improvements in body mass index (BMI). The BMI is a non-obtrusive objective measure of health status, and considered a gold standard health index. Child BMI will be interpreted based on CDC percentiles for BMI [35].

| Table 4 | Goal setting. |
|-------------|----------------|
| Complete from Last Week | Physical Activity |
| Caregiver | Did you meet your daily step goal? |
| | Did you complete any workouts in your weekly PA worksheet? |
| | How many workouts did you complete? |
| Child on the Autism Spectrum | Did they meet their daily step goal? |
| | Did they complete any workouts in their weekly PA worksheet? |
| | How many workouts did they complete? |
| Family | Did your family engage in any other PA this week? |
| | How many extra minutes of PA did you participate in as a family? |
| Complete for Next Week | Physical Activity |
| Caregiver | How many steps do you want to take per day this week? |
| | How many days this week do you want to reach your step goal? |
| Child on the Autism Spectrum | Did your child want to take per day this week? |
| | How many days this week do you want to reach your step goal? |
| Nutrition | Did your family pick up the ingredients last week? |
| Family | Did your family attempt to assemble the ingredients? |
| | Did you consume the snack? |
| Did your child on the autism spectrum consume the snack? |
Data syncing will provide continuous remote monitoring of PA participation. This monitoring will occur daily on each day of the week. This monitoring will reflect raw data in steps and activity counts. MovBands have been used in prior research, including in pediatric populations, and have demonstrated acceptable convergent validity with Actigraph accelerometers ([24], 2019; [36,37]). All participants, including children and caregivers, will be instructed to wear the MovBand during waking daytime hours on each day of the week. This monitoring will occur continuously across the 12-month period. Evening wear time is optional.

To measure objective PA, all children on the autism spectrum as well as their primary caregivers will wear a Movband 5 throughout the duration of the 1-year longitudinal intervention. MovBands are wrist accelerometers, and are similar in size and function to commercially available health watches (e.g., Fitbit) which count total movements, steps, heart rate, and calories (kcals) expended. MovBands have been used in prior research, including in pediatric populations, and have demonstrated acceptable convergent validity with Actigraph accelerometers ([24], 2019; [36,37]). All participants, including children and caregivers, will be instructed to wear the MovBand during waking daytime hours on each day of the week. This monitoring will occur continuously across the 12-month period. Evening wear time is optional. Remote monitoring of PA participation will be accomplished by weekly ‘data synching’. Each family will open the Movband app on a personal device and connect their designated MovBand device. Families will also be instructed on how to charge the device weekly using a USB adapter. Data syncing will provide continuous remote monitoring of PA participation throughout the intervention. Raw data in steps and activity counts will be summarized across each day and then analyzed to reflect the average PA level for each week. The primary outcome variable of interest in this study is the change to average steps per day across the intervention. In this way, the continuous monitoring of PA will afford researchers an opportunity to understand how the intervention may influence trajectories of activity.

To examine improved knowledge of quality of snack, meal and beverage options, five USDA ‘Choose MyPlate’ quizzes will be administered to caregivers. The quizzes each include five multiple choice questions related to each MyPlate category (e.g., dairy, fruit, grains, protein, vegetables). Raw scores will be calculated for each category and an overall sum score of all quizzes will be generated based on category raw totals.

In order to evaluate the improvements to nutrition behaviors during snack and mealtime, the Brief Autism Mealtime Behavior Inventory – Revised (BAMBI [38]) will be administered. The BAMBI is an 18-item caregiver report questionnaire that is scored based on a 1–5 likert scale and includes 4 subscales including food selectivity, disruptive mealtime behaviors, food refusal, and mealtime rigidity. The total frequency score will be calculated, where higher scores reflect more problematic behaviors.

2.14. Second objective: health behaviors

To evaluate improvements in PA, several objective and subjective evaluations will be administered. For children, we will administer questions from the United States Report Card on PA for Children and Youth (available at physicalactivityplan.org). The questionnaire will be administered to parents and captures the child’s community and activity participation over the previous 6 months. Questions are meant to capture a wide range of activities including; active transportation (to and from school), participation in community activities (recreational play), frequency of physical education, dosage of therapy (e.g., applied behavior analysis, occupational/physical therapy), and the built environment. Therefore, to distinguish the effects that may be a result of participation in PLANE, we plan to consider the time spent in any of these additional activities. These qualitative and quantitative data will be derived and evaluated to demonstrate changes to PA lifestyles across the one-year intervention.

To evaluate improvements in PA for caregivers, we will administer the International PA Questionnaires – Short Form (IPAQ-SF; [56]). This assessment was developed to measure health related PA and solicits information regarding participation in PA, including sedentary time (e.g., screen time). The results from the questionnaire data will be used to understand and describe levels and patterns of PA including sedentary behavior.

To measure objective PA, all children on the autism spectrum as well as their primary caregivers will wear a Movband 5 throughout the duration of the 1-year longitudinal intervention. MovBands are wrist accelerometers, and are similar in size and function to commercially available health watches (e.g., Fitbit) which count total movements, steps, heart rate, and calories (kcals) expended. MovBands have been used in prior research, including in pediatric populations, and have demonstrated acceptable convergent validity with Actigraph accelerometers ([24], 2019; [36,37]). All participants, including children and caregivers, will be instructed to wear the MovBand during waking daytime hours on each day of the week. This monitoring will occur continuously across the 12-month period. Evening wear time is optional. Remote monitoring of PA participation will be accomplished by weekly ‘data synching’. Each family will open the Movband app on a personal device and connect their designated MovBand device. Families will also be instructed on how to charge the device weekly using a USB adapter. Data syncing will provide continuous remote monitoring of PA participation throughout the intervention. Raw data in steps and activity counts will be summarized across each day and then analyzed to reflect the average PA level for each week. The primary outcome variable of interest in this study is the change to average steps per day across the intervention. In this way, the continuous monitoring of PA will afford researchers an opportunity to understand how the intervention may influence trajectories of activity.

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2.15. Third objective: quality of life

Finally, to capture any other improvements as result of participation in this comprehensive intervention, several behavioral health questionnaires will be administered. First, the Pediatric Quality of Life Inventory 4.0 (PedsQL; 57), is a brief measure of health related quality of life in children and includes 23 items that can be separated into core scales including: physical functioning, emotional functioning, social functioning, and school functioning. The questionnaire is taken as a caregiver proxy, reporting on child quality of life. A total physical health summary score will be generated based on the raw totals from each category.

Next, the Depression and Anxiety Stress Scale (DASS) [39] will be administered to parents. The DASS is a 42 item self-report evaluation that measures three negative emotion states including depression, anxiety, and tension/stress. A sum score for each scale will be generated and then raw totals will be multiplied by 2 to generate domain scores. Taken together, these assessments will provide a more comprehensive evaluation of health beyond the physical parameters named above.

2.16. Fourth objective: feasibility and fidelity

To evaluate the feasibility of participation adherence to PLANE programming, attendance will be taken at several points throughout the week. First, attendance will be taken at the weekly ingredient distribution event. Attendance include the availability to pick up directly or the availability to arrange for an ingredient drop off at home. Second, attendance at live synchronous Zoom sessions will be taken. Third, completion of the goal setting survey will serve as an additional way to monitor program participation. An email follow up will be sent to primary caregivers if attendance at any one of the adherence check points is missed. Finally, meta-data, based on clicks and views of interactive workshees, YouTube videos, and other digital resources will be used to continuously evaluate engagement.

To examine fidelity of the coaches, a fidelity checklist will be administered by the principal investigator (see Table 2). The fidelity checklist is meant for the synchronous PA Zoom sessions only. Fidelity outcomes will be discussed during a weekly PLANE coaches meeting, in this way, we will ensure all coaches are maintaining a high degree of consistency within the delivery of synchronous Zoom sessions.

2.17. Statistical analysis

The first three objectives relate to improvement in weight status, PA levels, nutrition behaviors, and quality of life of both children on the
autism spectrum and caregivers. The intervention was powered based on a moderate effect size ($f = 0.25$), across the four measurements with ($r = 0.50$) between measures. This effect size reflects an absolute change of approximately 0.50 standard deviations on each outcome. GPower® 3.1.9.7 calculated a sample of 24 participants per group for 81.7% power. To allow for up to 25% attrition, a minimum of 30 children with ASD and 30 parents will be included within each age band (i.e., 2–5, 6–12, and 13–18). To compare changes in the primary outcome variables (BMI, PA level, nutrition, QoL) from 0 to 12 months, repeated measures MANCOVA will be employed. Analyses will be addressed separately between children with ASD and parents. Additionally, child outcomes will be evaluated across age bands. The fourth objective of intervention feasibility and fidelity will be examined through descriptive statistics on attendance, goal setting, monitor wear. Differences in adherence will be examined across children and parents as well as across child age bands.

Missing data is likely to occur due to the 12-month span of the program, number of programming components, and outcome variables being measured. Both intent-to-treat (ITT) and per protocol analyses evaluate program outcomes in light of participant drop out. When missing data occurs at random, including due to attrition in ITT analyses, multiple imputation procedures will be employed. The procedure will be based on all measured variables and will impute a minimum of 10 separate complete datasets that will be used for subsequent analyses [40,41].

3. Discussion

3.1. Justification for PLANE

Relative to their neurotypical peers, youth on the autism spectrum, as well as their parents, represent an underserved population of the United States. Current research suggests that health disparities in children on the autism spectrum emerge early on and continue to increase throughout development [2,4]. Lack of participation in PA and poor nutritional practices are known contributors to the presence of health disparities among children on the autism spectrum. To date, the majority of intervention approaches for children on the autism spectrum focus on addressing the core deficits in social and communication domains [18,42]. This is despite significant health disparities that are present in this population, including a disproportionate number of children on the autism spectrum who are overweight or obese [5]. Additionally, parents of children on the autism spectrum have been identified as a vulnerable population to experience health disparities including chronic stress and low perceived health competence [18].

Telehealth interventions including videoconferencing and caregiver training has emerged as a timely and effective alternative to traditional face to face treatment delivery. In fact, telehealth interventions can reduce a variety of barriers including rural and urban accessibility, time away from work/school for travel, and service provider burnout [43]. Moreover, telehealth has been cited as a cost-effective model given its potential to be scalable and sustainable [15]. To address the timely need for telehealth programming, and to address several gaps in the literature related to health promotion interventions for vulnerable populations, PLANE, a one-year longitudinal telehealth physical literacy and nutrition education program will be delivered to children on the autism spectrum, as well as their families.

While the promotion of physical activity, especially early on in development is a key factor in promoting positive trajectories of health, when compared to their neurotypical peers very little is understood regarding the patterns and levels of participation in children on the autism spectrum. Several studies have suggested that children on the autism spectrum engage in less than the recommended amounts of daily PA [44,45], however, one study reported children on autism spectrum (aged 4–6) accumulated significantly more time in daily health related PA than their neurotypical peers [46]. Of particular note is that results were based on objective measures of PA considered gold standard for PA evaluation. Another finding related to PA are the age-related declines in children on the autism spectrum who participate in less health enhancing PA throughout adolescence [7]. One factor contributing to inconsistent PA findings are the discrepancies in monitoring, including differences between subjective and objective measurement. These findings underscore the need for well-designed studies that include robust measurements of PA. Because many children exhibit stereotypic behaviors including body rocking or hand flapping, parents may be unsure how to categorize these movements within PA intensities. As recommended in Ketcheson et al. [31], this study will incorporate both objective PA measurements alongside caregiver reports of PA. Together, these measures will help to describe how PA is being accumulated.

Because the pervasiveness of behavioral challenges in children on the autism spectrum span across several domain, parents often report receiving very little training on how to navigate the presence of a feeding disorder [47]. Unfortunately, behavioral challenges during family meal/snack time coupled with the presence of feeding disorders present several barriers to the adoption of healthy eating behaviors. Several studies have demonstrated through caregiver training [48] or intensive behavioral therapy [49], an increase in shared family snack/meal experiences and healthy eating behaviors can be promoted. Presenting parents with a curriculum aligned with USDA standards, that is sensitive to the diversity of feeding disorders among children on the autism spectrum is a key component to PLANE primary goal of promoting positive trajectories of health. Long term maintenance of improved weight status following a PA or nutrition intervention has limited success. This is in part due to the participation in interventions which targets a singular component of health. Moreover, these programs rarely offer a maintenance or ongoing opportunity to engage in intervention components. Key to PLANE is the simultaneous inclusion of both PA as well as nutrition education, and the telehealth framework which offers an ongoing and sustainable long-term way to engage with curriculum components.

An often-overlooked population at greater risk to experience significant health disparities are caregivers of children with IDD, including children on the autism spectrum. Current research suggests caring for a child with a disability is a stressful responsibility that negatively impacts the health of primary caregivers [50]. While the majority of research to date has focused on the psychological health of caregivers, there is some empirical support examining the relationship between a chronic level stress (as a result of raising a child with disability) and negative caregiver health outcomes. In one study, the role of social support as a mitigator to negative health outcomes were examined among parents of children on the autism spectrum and children with attention deficit hyperactivity disorder (ADHD) [51]. Results suggest an inverse correlation between physical health complaints and the perceived availability of social resources, suggesting caregivers experienced fewer health issues if they had ample social support [51]. Next, parents of individuals with disabilities are more predisposed to experience both high levels of chronic health issues, as well as a high rate of participation in health risk behaviors, for example smoking and drinking [52]. Interestingly, these findings persisted even after controlling for socioeconomic and demographic factors [52]. The development of interventions to encourage health promoting behaviors among caregivers of children with disabilities are critically needed for this population. When taken together, PLANE fills a gap in the literature by offering a framework easily accessible to parents, with simultaneous participation for their children on the autism spectrum.

3.2. Scalability, sustainability, and replicability

While an initial investment in time and effort was required to create PLANE social media platforms and website, overtime, PLANE represents a scalable and sustainable telehealth intervention. While the delivery of
an in-person PA intervention for children on the autism spectrum has been established [30], the sustainability of such a program requires consistent brick and mortar space availability, ample ‘coach’ support for 1:1 program delivery, as well as frequent transportation to the intervention site. A telehealth health promotion intervention represents a sustainable service delivery model that reduces many of these implementation barriers. Next, PLANE represents a program easily replicated by schools, clinics or community-based partners. While methods for PLANE delivery outlined in this manuscript include an initial gift of sports equipment/nutrition supplies, as well as ongoing food distribution events, each of these programming aspects can be modified. For example, in lieu of providing the sports equipment to keep, a loan program could be set up with a community partner where different pieces of equipment were ‘signed out’ for a designed amount of time. Additionally, instead of a weekly food distribution event, recipe cards with specified ingredients for purchase could be disseminated each week. Alternatively, if a cost for enrollment into PLANE was solicited (or sustainable service delivery model that reduces many of these implementation barriers. Next, PLANE represents a program easily replicated by schools, clinics or community-based partners. While methods for PLANE delivery outlined in this manuscript include an initial gift of sports equipment/nutrition supplies, as well as ongoing food distribution events, each of these programming aspects can be modified. For example, in lieu of providing the sports equipment to keep, a loan program could be set up with a community partner where different pieces of equipment were ‘signed out’ for a designed amount of time. Alternatively, if a cost for enrollment into PLANE was solicited (or external funding to host PLANE was secured), then interventionists could weigh the costs associated with an initial supply of sports equipment/nutrition supplies and/or the use of a grocery delivery service or gift card to purchase ingredients. Given maintenance to health promotion programs has been identified as a critical need among children on the autism spectrum [30], all PLANE curriculum will be housed online, including a designated website, a YouTube channel, and interactive worksheets, to be accessible asynchronously in perpetuity.

3.3. Accessibility, removing participation barriers

The use of videoconferencing to deliver interventions in real time have been cited as a popular alternative to face-to-face appointments given the reduction of implementation barriers including reaching urban residents and removal of travel and time from work/school [43]. Additionally, unique barriers have been identified as inhibitors to PA participation in families who have children with IDD including a lack of qualified staff, little community support, and funding [25]. The global pandemic has only heightened the health disparities experienced by children on the autism spectrum [53]. As such, it is imperative service providers continue to find alternative ways to promote positive trajectories of health. The PLANE program represents an accessible telehealth PA and nutrition education intervention given the majority of intervention components can be hosted virtually. While PLANE does require a caregiver investment in time, it can operate with far fewer staff than traditional in-person interventions, in turn reducing cost to participate and increasing accessibility for enrollment.

3.4. Limitations

First, we acknowledge the lack of a control group is a limitation of this research study. Our funder, the Michigan Health Endowment Fund, was specifically interested in supporting the community-based intervention. Thus, all participants need to receive the PLANE intervention through this study. Once the feasibility of the PLANE program is established through this study, proper experimentally controlled research designs will be needed to investigate the efficacy of the program. We do believe, however, that the program represents a sustainable model of health intervention for children with ASD that can be replicated and scaled to the community.

The extended timeline of the PLANE program over a 12 month period may also create challenges for attrition of participating families. To account for this challenge, we will attempt to be transparent with participating families with the timeline of the study, make each intervention (e.g., intervention, evaluation measurements) as meaningful as possible, and be persistent with communication across the time period. Furthermore, our power analysis for statistics currently allows for up to 15% attrition before falling below the 80% power threshold. If necessary, intent-to-treat analyses and multiple imputation techniques will be employed to properly address missing data.

Lastly, families may experience challenges to consistently participate in the virtual PLANE intervention, especially for families with lower socioeconomic status. Internet access is needed for synchronous and asynchronous study activities. If families experience temporary outages or lapses, the city where the intervention is proposed has access to community ‘wifi hotspots’ which provide public access to internet. Families that do not have consistent internet access will be provided with a list of these hotspot locations to permit access to study materials.

3.5. Conclusion

The need for technology supported interventions is of growing relevance given COVID 19. Telehealth interventions have been identified as a cost-effective alternative to traditional treatment options, moreover, telehealth interventions have shown promising results in children on the autism spectrum when reducing core deficits. Most importantly, there is recent empirical support demonstrating that the delivery of physical exercise program in a telehealth format is feasible and enjoyable [15,29]. An often-overlooked population that is vulnerable to experience additional stress and health disparities includes parents of children with developmental disabilities. In sum, justification for the conceptualization and delivery of PLANE is well warranted, and represents a promising intervention which is scalable, sustainable, and replicable.

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Author’s contributions

Both Drs. Ketcheson and Pitchford contributed to the conceptualization of PLANE, and in the current written manuscript submission.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Appendix
Fig. 1. PdF - child physical activity: asynchronous.
Fig. 2. Pdf - adult physical activity: asynchronous.
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