Families Becoming Healthy Together – Protocol and Statistical Analysis Plan

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The protocol and analyses below were what was proposed in the initial submission. This trial occurred during the COVID-19 pandemic, which affected implementation of the trial. As this trial was designed to be implemented in person, all methods, recruitment, assessment, and intervention eventually were moved to remote methods. This impacted the sample size, implementation of the intervention, and ability to collect follow-up data. After the pandemic started, to maximize the ability to collect the primary anthropometric outcome, the incentives provided for assessment data collection were split across the differing measures, thus more follow-up data were collected for anthropometrics than any other data. Follow-up data collection varied across the measures. There is heterogeneity of how the changes in implementation occurred across the participants.

2. Methods

2.1. Study Design and Aims

Families Becoming Healthy Together is an 18-month randomized clinical trial of FBT versus FBT with a limited RED food variety prescription (FBT+Variety), in which a dyad of a child with overweight or obesity and an adult caregiver with overweight or obesity is randomized to one of the two interventions. The trial is funded by the National Institute of Diabetes and Digestive and Kidney Disease (1R01DK121360-01) and is registered at clinicaltrials.gov (NCT04027426). The study was approved by the University of Tennessee Knoxville (UTK) Institutional Review Board (IRB), with the IRBs of The Miriam Hospital, The University of Buffalo, and The University of Memphis establishing reliance agreements with UTK's IRB. All adult participants are asked to provide written informed consent and all child participants are asked to provide assent for participation. Assessments occur every 6 months during the trial (0, 6, 12, and 18 months). There are two primary aims of the study, which are focused on

determining the influence of FBT+Variety on long-term (18-month) change in BMI and habituation to RED foods. These aims also examine if habituation rate mediates the relationship between limited variety and changes in dietary intake and BMI between the two conditions. Finally, an exploratory aim of this study is to determine the influence of baseline habituation rate on moderating outcomes in FBT+Variety and FBT, which will allow for the identification of a behavioral phenotype that bests benefits from a limited variety prescription.

2.2. Participant Eligibility Criteria and Recruitment

This investigation will include 156 children meeting the following criteria: 1) age between 8 and 12 years; 2) $\geq$ 85th percentile BMI; and 3) one adult caregiver ($\geq$ 18 years) living in the household with a BMI $\geq$ 25 kg/m^2 and willing to attend treatment meetings.

Participants will be excluded if: 1) child and adult caregiver report living in two separate households for > 2 days per week; 2) child or adult caregiver report a heart condition, chest pain during periods of activity or rest, or loss of consciousness on the Physical Activity Readiness Questionnaire (PAR-Q) [18] (individuals reporting joint problems, prescription medication usage, or other medical conditions that could limit exercise will be required to obtain written primary care provider consent to participate); 3) child or adult caregiver report being unable to walk for 2 blocks (1/4 mile) without stopping; 4) child or adult caregiver report major psychiatric diseases or organic brain syndromes; 5) child or adult caregiver report currently participating in a weight loss program and/or taking weight loss or appetite regulation medication or lost > 5% of body weight during the past 6 months; 6) child report having bariatric surgery for weight loss/planning to have bariatric surgery in the next 18 months, adult caregiver report having bariatric surgery in the previous two years or planning to have bariatric surgery in the next 18 months; 7) adult caregiver reports being pregnant, lactating, less than 6 months post-partum or

planning to become pregnant in the next 18 months; 8) child or adult caregiver report planning to move outside of the metropolitan area within the time frame of the investigation; 9) child or adult caregiver report dietary restrictions for medical reasons; 10) child or adult caregiver report allergies to lemon or lime juice (used in habituation measures); and 11) child is not able to read at a third-grade reading level. Due to potential need for primary care provider consent, families must also be able to identify a primary care provider to participate in the study.

Families will be recruited through social media and advertisements in newspapers, direct mailings, and flyers posted around the greater metropolitan Knoxville, TN area, including in health care provider offices and other locations in which families may attend. Families will also be recruited via community events (i.e., farmer's markets, health expos). Finally, families will be recruited from pediatrician's offices interested in completing IRB-approved direct referrals. Interested potential families will be phone-screened for eligibility. Those that meet eligibility criteria will be invited to an orientation, at which informed consent and assent will be obtained.

2.3. Randomization

Proper randomization will avoid imbalance between treatment conditions in known and unknown prognostic factors. Weight status (85th to < 95th BMI percentile vs. $\geq$ 95th BMI percentile), child gender (male vs female), and ethnical or racial minority status (minority vs non-minority) are three potentially important prognostic factors that will be addressed in the randomization scheme. Stratification by prognostic factors is a common way to avoid imbalances in randomized clinical trials but may result in small or empty cells when the total sample size is small. This is also particularly problematic in cases (such as the current trial) where the treatment trial design involves group-based intervention wherein multiple families' simultaneously attend the same intervention and/or are unable to meet at certain times due to schedule conflicts. As

such, treatment group times (earlier evening [5:30 pm] vs. later evening [7:00 pm]) will be randomized to the FBT or FBT+Variety intervention conditions using an "urn design" adaptive probability algorithm developed and described in Stout and colleagues in 1994 [19, 20]. The urn design is widely used in randomized clinical trials where several prognostic factors need to be balanced and the sample size is relatively small (typically, <200). Simulations demonstrate that this procedure produces a higher probability of balanced randomization to treatment conditions than traditional fixed allocation procedures such as stratification. More specifically, for each treatment time to be randomized, the algorithm will consider the status (average proportion: 0%-33% vs. 34%-67% vs. 68-100%), on the three prognostic factors (male sex, $\geq 95^{th}$ percentile BMI, % identifying as racial or ethnic minority) in making an overall assessment of the group balance or lack of balance. If any residual imbalance occurs in prognostic factors, these factors will be incorporated into the analysis plan as covariates. Families will be informed of their randomized condition at the first group meeting (group meetings will only contain families in the same condition).

3. Study Intervention

3.1. Intervention Framework - FBT

The FBT used in the investigation meets the U.S. Preventive Services Task Force [21] and the American Psychological Association [22] recommendation regarding the use of a comprehensive, intensive intervention for childhood obesity. These recommended interventions use a family-based approach, in which diet and physical activity and/or sedentary behavior goals are provided in combination with behavioral parenting strategies to assist children with meeting provided goals. These interventions provide $\geq$ 26 hours of contact time.

FBT is a specific comprehensive intervention for childhood obesity [1]. It is a multi-component treatment, which includes diet and physical activity and/or sedentary behavior goals, and behavioral parenting strategies to assist children with behavior changes. Additionally, adult caregivers are robustly engaged in treatment, as behavioral (diet, physical activity, and/or sedentary behavior) and weight goals are targeted in both children and adults. Adult caregivers are also using behavioral strategies to change their own diet, physical activity, and/or sedentary behaviors. They are encouraged to model healthy eating and activity behaviors, and act as agents of change for their children. Engaging caregivers in this manner appears to be important for outcomes, as caregivers who lose the most weight in the program have children who have the greatest improvements in weight status [23].

3.1.1 Dietary goals

Participants in both interventions will be instructed to follow the Traffic Light Diet [17, 24]. The Traffic Light Diet categorizes foods into the colors of the traffic light: GREEN, YELLOW, and RED. The categorization is based upon a food item's energy, fat, and added sugar content. In general, only vegetables are considered GREEN foods. YELLOW and RED foods are determined by caloric cut-offs per serving for each food group (vegetables; starchy vegetables; fruit; grains; dairy; protein; soups; and condiments, dressings, and other ingredients). All foods categorized as fats, oils, added sugars, and others; and fruit juices and dried fruits are considered RED foods regardless of the calories per serving. Furthermore, modified foods categorized as fats, oils, added sugars, and others (i.e., reduced-fat cookies), which may be lower in energy, fat, and/or added sugar than their non-modified counterparts are also considered RED foods, as these foods generally still contribute few nutrients to the diet and compete for consumption of healthier foods. Combination foods, foods that are comprised of several

individual foods (i.e., pizza, hamburger, lasagna), will be considered RED foods if one of the individual foods in the combination food is a RED food and contributes one or more servings of RED food or if one serving of the combination food has more than 5 g of fat per serving. Participants will be instructed to consume between 1000–1500 kcal per day, with a goal of ≤2 servings of RED foods per day. Participants will be instructed to eat the size and number of servings from the differing food groups as recommended in the Dietary Guidelines [25]. Families will develop weekly meal plans to assist them with achieving these dietary goals.

Energy goals will be adjusted as needed for each individual participant for weight loss. When participants' weight decreases so that they are within the healthy weight range, they will be given the option of eating an additional 100 kcal per day in the form of GREEN and YELLOW foods until no more weight loss or weight gain occurred. Once that new caloric intake is determined, participants will be encouraged to maintain calorie intake consistent to achieve weight maintenance.

3.1.2. Physical activity goals

The goal will be to increase moderate- to vigorous-intensity physical activity (MVPA) to meet recommended guidelines (≥ 60 minutes/day [children] or 150 minutes/week [adults], structured as ≥ 30 minutes/day at least 5 times/week to assist with forming daily habits) [26]. As some participants may likely be inactive coming into the intervention, participants will shape their physical activity to meet the targeted goals. Initially participants will be encouraged to complete ≥ 10 minutes/day 5 times/week at a moderate-intensity activity level starting at week 2, and then increase physical activity 10 minutes/day (child) and 5 minutes/day (adult) each week until they have reached the intervention goal. Children will be encouraged to do developmentally appropriate play activities and family-based physical activities (e.g., go for a family walk or a

bike ride) and adult caregivers will be encouraged to do brisk walking and other aerobic activities, as well as family-based physical activities.

3.1.3. Behavioral strategies

Families will be instructed in behavioral skills, which form the basis of FBT [27]. The skills are based on Social Cognitive Theory. All strategies are introduced by the fourth month of the intervention, with review of all strategies occurring over the course of the intervention. Strategies provided to participants include self-monitoring, positive reinforcement, stimulus control, modeling, pre-planning and problem solving, goal setting, and relapse prevention.

Self-monitoring is introduced in the first session and is focused on throughout the intervention. Both children and adult caregivers will self-monitor daily intake by documenting food and beverage description; amount of food and beverage; calories; servings of RED foods; and if RED foods consumed were their chosen RED food (FBT+Variety only). FBT+Variety will also self-monitor weekly frequency of consumption of chosen RED foods and other RED foods per week. To accommodate the needs of families in the investigation, families will choose to self-monitor eating using technology (app on a smartphone, such as MyFitnessPal) or via written diaries. Given that no app tracks RED foods, all families will be asked to identify RED foods within their method of self-monitoring. For self-monitoring daily physical activity (MVPA minutes), families will be provided with two (one for the child [Garmin] and one for the parent [Fitbit]) wearable wrist activity trackers. Self-monitoring records (either in hard copy or electronic form) will be reviewed by an interventionist so that individualized feedback can be provided to families to assist them with meeting diet and physical activity goals. The self-monitoring and feedback will occur throughout the 18–month intervention. Families will also self-weigh at home weekly.

Caregivers will be taught to praise children for meeting goals specific to their intervention. In addition, caregivers will provide children points for meeting dietary and physical activity goals, and weight loss. Children will exchange points for mutually agreed upon reinforcers chosen from a reinforcement menu that will include privileges and activities that the child indicates he/she likes and the adult caregiver agrees to provide. Reinforcers could include special time with adult caregivers and family members, having a sleepover, or a family trip or gathering. Reinforcers will not include food or material gifts. The purpose of both types of positive reinforcement are to establish and maintain behavior change in the children.

Altering the home environment, by reducing cues that prompt eating, consumption of RED foods, consumption of a variety of RED foods (FBT+Variety only) and increasing cues that encourage physical activity will be encouraged (stimulus control). For example, foods will be encouraged to be stored in places out of sight upon walking into any room, and equipment needed for physical activity (e.g., bikes, balls) will be stored in visible, easily accessible places for children.

As is traditional in a family-based approach, the caregiver will also change the same dietary and physical activity behaviors as the child, as adult caregivers can then model healthy behaviors for the child, assisting the child in learning the new weight-related behaviors [28]. Additionally, families will be encouraged to consume meals together and engage in physical activity together (e.g., go for a family walk or bike ride), providing opportunities for adult caregivers to model targeted behaviors in front of their children.

Preplanning and problem solving will be taught to facilitate decision making for difficult eating and activity situations, such as parties, holiday gatherings, restaurant eating, vacations, and school or work functions. Participants will be instructed to identify specific problems,

brainstorm solutions, choose a solution, develop and implement a plan, and evaluate the plan's success. Furthermore, all families will develop weekly meal plans to assist them with achieving the dietary goals specific for their condition. Families in FBT+Variety will develop meal plans that repeat their chosen RED dinner entree and snack food, include leftover foods from their meal in which their chosen entrée was initially prepared, and reduce variety of RED foods. Families in FBT+Variety will also be encouraged to repeat weekly meals plans over the course of the intervention.

The importance of short- and long-term goal setting for successful behavior change will be taught to families. Shaping will be introduced and used for changing MVPA as rapid changes in this behavior increases risk of injury.

Based on Marlatt and Gordon's Relapse Prevention Model [29], families will be instructed to prepare and plan for lapses in eating and activity behaviors. Identifying and anticipating high-risk situations, and developing a detailed plan for these situations will be encouraged.

3.1.4. Family meetings

Families will be encouraged to have a brief daily family meeting. Families will be instructed that these meetings provide the opportunity for the adult caregiver to review self-monitoring of the child, ascertain child progress on eating and activity goals, answer child questions, problem-solve issues, and pre-plan situations as needed. These meetings also afford the opportunity for the adult caregiver to provide positive reinforcement (i.e., praise, points, reinforcers) and emotional support to the child and model behaviors (i.e., self-monitoring, meeting goals, problem solving, pre-planning).

3.1.5. Treatment structure

Intervention will be delivered via group meetings once a week for months 1 to 4, twice a month for months 5 to 6, once a month for months 7 to 12, and once every two months for months 13 to 18 (29 sessions). For all meetings, child and adult caregiver weight will be reviewed and feedback regarding the relationship between weight change and eating and activity behaviors will be discussed with each family. At the start of each group meeting, a "check-in" occurs, in which progress on the behavioral goals and use of the behavioral strategies is reviewed, and a behavioral lesson, using the behavioral strategies as topics for these lessons, will be presented. At the 60-min meetings, the child and adult will attend separate 40-min group meetings, and then for the last 20 min of the meetings they will meet together to engage in a family activity to address specific family-issues (e.g., challenges with meeting dietary goals) by developing behavioral action plans with the support of an interventionist. Individuals with training at the master- or doctorate-level in nutrition, exercise physiology, or behavioral psychology will lead the group meetings and meet with families.

3.2 Intervention Framework – FBT+Variety

Habituation theory provides a framework for how repeated presentation of a stimulus, such as repeated bites and tastes of a food, influences responding to the stimulus [6]. As previously stated, habituation is demonstrated by a reduction in physiological and behavioral responses to repeated presentation of a stimulus [6]. The reduction in response is not due to adaptation or fatigue, as presentation of a new stimulus causes the response to reoccur (dishabituation) [30]. Habituation theory is important in understanding food intake, as eating involves the repeated presentation of food stimuli (visual, olfactory, and gustatory stimuli), both within and across eating occasions. Thus, habituation theory can provide a model for understanding factors that influence the rate of reduction of responding to repeated food stimuli.

Indeed, the rate of habituation is related to the amount of food consumed, such that a faster rate of habituation is related to a significantly lower amount of food consumed [30].

As a novel food cue produces dishabituation, presenting a variety of food cues across trials should slow down the overall rate of habituation [6]. Indeed, our research with children and adults has found that during a laboratory session, as compared to being presented with the same food cue over multiple trials in a session, presenting different food cues, either as completely different foods or the same food with differing flavors, over trials slows down habituation rate [31-34]. Furthermore, this slower habituation rate produces greater energy intake in laboratory sessions [31, 33, 34]. We have also examined the effect of food variety on habituation rate and intake over time periods longer than one laboratory session (long-term habituation) and have found in these situations variety conditions produce slower habituation rates and greater energy intake [35].

We have started to investigate the effect of applying habituation theory using the variety paradigm within obesity treatment. We have examined how dietary variety influences weight management in both secondary analyses and within randomized trials [5, 36-39]. In a secondary data analysis, we found that adults with overweight or obesity participating in a traditional lifestyle intervention who made the greatest reduction in the number of different non-nutrient-dense, high-energy-dense foods (i.e., “snack foods” such as cookies, cake, chips) consumed had greater reductions in caloric and percent dietary fat intake and greater weight loss at 6 months [36]. We also examined the relationship between food group variety and long-term weight loss maintenance in the National Weight Control Registry [39]. When Registry members were compared to individuals who had lost at least 7% of their initial weight after participating in a 6-

month lifestyle intervention, Registry participants reported consuming significantly less variety in most food groups, but especially in those food groups higher in fat density [39].

We have begun to harness and translate the effects of habituation on intake within the context of obesity treatment by developing dietary goals that focus on reducing variety in high-energy-dense foods to assist with reducing energy intake [5, 37, 38]. Our latest "proof-of-concept" testing indicated that limited variety goals achieved a clinically relevant outcome [5]. Within a 6-month pilot study, 24 families, with a child $\geq 85^{th}$ percentile BMI and aged 8 to 12 years, were randomized to FBT or FBT+Variety. Families in FBT+Variety identified two RED foods each month that they would consume during that month. These were RED foods usually consumed, rather than new RED foods introduced to their diet. The chosen RED foods were one dinner entrée and one snack food. Families in FBT+Variety developed monthly meal plans that repeated dinner entrees and reduced variety of other RED foods. Families were encouraged to repeat weekly meal plans each month. Significant between group differences in child percent overweight were found (FBT+Variety−15.4% vs. FBT − 8.9%, p = 0.017). Variety of RED foods showed a significant between group change by family (FBT+Variety = 20.2 to 12.6 vs. FBT = 19.7 to 16.8, p = 0.01) [5].

FBT+Variety in the current investigation will be similar to what was tested in our intervention in the pilot study. FBT+Variety will contain all components of FBT and include an additional dietary goal to reduce RED food variety. At the start of each month, families will identify two RED foods, one dinner entrée and one snack food, they will regularly consume during the month, while limiting consumption of other RED foods. Over the course of the 18-month intervention, families will be encouraged to repeat their two monthly RED food choices, with repetition occurring on months 1, 6, 12, and 18, to further assist with habituation. Entrees

will be classified as those foods providing the largest amount of energy at a dinner meal (e.g., pizza, pasta dish, casserole, hamburger/sandwich, meat). Snack foods will be classified as foods that are commonly eaten as part of a meal, but not as an entrée, or snack (e.g., baked goods, granola/snack bars, high-fat crackers, flavored popcorn, frozen dairy-based desserts, ice cream, candy, chips, salty snacks) [38]. Families will be encouraged to pick RED foods previously consumed (to not introduce new foods in the diet) and feel they can consume while also meeting their calorie and RED food servings goals (i.e., they will be advised to not choose RED foods in which it would be challenging to consume only one serving at a time). The flavor of each chosen RED food will also be defined. For example, rather than just selecting ice cream for their chosen RED snack food, participants will choose the flavor of ice cream, such as strawberry ice cream. Families in FBT+Variety will have a goal of consuming the chosen entree $\geq$ 2 times per week and the snack food $\geq$ 4 times per week (any size of serving consumed of these foods will count towards the goal, but families will be encouraged to consume $\leq$ 1 serving of these foods each time so that they stay within the kcal goal). These goals should assist with repeated exposure of these foods, as well as limit consumption of other RED foods, enhancing habituation.

The first RED snack food chosen will be selected during baseline assessments to allow for baseline habituation measures. The first chosen RED dinner entrée will be selected at the start of treatment. These selected RED foods will be the foods consumed at 1, 6, 12, and 18 months.

3.3. Outcome Measures

The primary outcome measures are BMI and salivary habituation. Secondary outcome measures are as follows: dietary intake; physical activity; percent overweight and waist circumference; meal planning, preparation, and grocery shopping; child eating pathology; home food inventory; sleep habits; child routines; and compliance and process data. All outcomes,

except for compliance and process data will be assessed every 6 months. The assessors will be blinded to the family treatment group.

At each assessment, participants will complete two measurement sessions, one week apart. During the first session, a salivary habituation measure will be taken, an accelerometer-based device (wGT9x, ActiGraph, LLC, Pensacola, FL) will be given to each participant to wear during the next week, and participants will be given a packet of take-home surveys that assess secondary outcome measures of meal planning, preparation, and grocery shopping, child eating pathology, home food inventory, child and adult sleep habits, and child routines. During the week between the two sessions, dietary intake will be assessed using three 24-hour recalls via phone. At the second session, the second habituation measure will be taken, and participants will return the wGT9x, and completed surveys.

3.3.1 Child and adult anthropometrics

Both the child's and adult caregiver's weight and height will be assessed using an electronic scale and a stadiometer, respectively. For the child, height and weight will be collected at the assessment visits that happen every 6 months. For the adult caregiver, height will be assessed at the first baseline appointment and weight will be assessed every 6 months. BMI will be calculated by weight in kg/height in m^2. The child's ZBMI score will be calculated based upon the value of the 50^{th} BMI percentile and the standard deviation of the age and sex appropriate sample from the Centers for Disease Control growth charts [40]. Percent overweight (%OW) will also be calculated (100*[BMI/50^{th} percentile BMI for child age and sex]) [41]. Waist circumference (WC) will be measured using standard procedures [42]. BMI is the primary anthropometric outcome.

3.3.2. Child and adult salivary habituation

To assess habituation of salivary responses to food cues, whole mouth parotid salivary flow will be measured using the Strongin-Hinsie Peck method [43]. Two measures will be taken, one with juice and one with food, with both measures involving 14 salivation trials. Prior to each assessment, participants—the adult caregiver and child dyad—will be given an energy bar (approximately 100 kcal in children and 200 kcal in adult caregivers and not similar in sensory qualities to foods used in the measure) to consume 3 hours prior to the measure and be instructed to not consume anything else but water prior to the measure.

At the start of the measure, participants will report the time of consumption of the last food or beverage that was not the provided energy bar, the time of consumption of the provided energy bar, and rate hunger and fullness on a 100 mm visual analogue scale (VAS) (anchors of extremely not hungry [full] and extremely hungry [full]). Participants will also rate their liking of the juice/food stimuli provided in the measures on a 100 mm VAS (anchors of extremely like and extremely dislike). Next, participants will be trained in the correct placement of three dental cotton rolls (cylindrical, 7 mm diameter, 38 mm length, Richmond Dental, Charlotte, NC); one on each side of the mouth between the cheek and lower gum and one under the tongue. Participants will be instructed not to swallow, talk, or move the cotton rolls once they have been placed in the mouth. Following the 14 salivary collection trials, participants will again rate their hunger and fullness on the VAS.

For the trials with juice stimuli, there will be 2 trials of water, 10 trials of lemon juice, and 2 trials of lime juice. After properly placing the dental cotton rolls in the mouth, a syringe with 0.1 ml of liquid will be given to the participant and the participant will be instructed to place the liquid onto the top of the tongue. While sitting still, the participant will wait for two minutes with the liquid on the tongue. After the two minutes are completed, any remaining liquid

will be spit into a cup, the cotton rolls will be removed and placed back into a plastic bag, and a two-minute rest period will begin. Participants will cleanse their mouth with water between each trial.

For the trials with food stimuli, there will be 2 trials of water, 10 trials of RED food, and 2 trials of GREEN food. The two water trials will be conducted as previously stated above. For the food trials, after properly placing the three dental cotton rolls in the mouth, participants will be given a 1 g piece of the food to place and hold on their tongue and be asked to hold a petri dish containing 4 grams of the food one inch away from their nose for the two-minute trial. After the two minutes are completed, the cotton rolls will be removed and placed back into a plastic bag, any remaining food will be swallowed, and a two-minute rest period will begin. Participants will cleanse their mouth with water between each trial.

For the habituation measure using food stimuli, the participants randomized to FBT+Variety will be given the RED food that is selected as their chosen RED snack food at the baseline assessment, which will also be consumed during the intervention at months 1, 6, 12, and 18. Child participants randomized to FBT will be given a RED snack food that was not selected as their chosen snack food during the baseline assessment. Each participant will receive the same RED snack food (i.e., their chosen or not their chosen) for each habituation measure. The GREEN food used in the measures will have no sensory similarity to any chosen RED snack food. Adult caregivers will receive the same RED snack food and GREEN food as their child. Participants will also be asked to report on the frequency of consumption of the RED snack food used in the habituation measure during the previous month.

3.3.3 Child and adult dietary intake

Dietary intake for both the child and adult caregiver will be assessed by 3 (2 weekdays and 1 weekend day) 24-hour dietary phone recalls, using the five-step, multiple-pass method. A researcher will contact the adult caregiver by phone to ask about all foods and beverages consumed the day prior. After completing the recall for the adult caregiver, the researcher will then repeat the process for the child with the assistance of the adult caregiver.

To enhance the validity of the phone recalls, an ecological momentary assessment platform (EMA) will be used by participants on their smartphones during the week between the two sessions to collect digital images of food and beverages at the beginning and end (showing food remaining) of all eating occasions over the 7 days. Researchers conducting the phone recalls will have access to the images during the 24-hour recall to prompt reporting of foods not described and to assist with accurate quantification of food portions consumed. Use of photos with 24-hour recalls has increased accuracy of reported energy intake as compared to weighed food intake, with no identified systematic bias [44].

The data collected from the recalls will then be entered into the Nutrition Data System Software for Research (NDSR; Nutrition Coordinating Center, University of Minnesota, Minneapolis, Minnesota). Variables of interest are the variety of RED foods consumed over the three days; and the mean over the three days of daily servings and kcal from RED foods, kcal, energy density (kcal/g), and Healthy Eating Index (HEI)-2015 [45]. Adherence to the prescriptions in the two conditions will be examined. At 6, 12, and 18 months, the percentage of goals met each day will be calculated, with a mean percentage calculated.

3.3.4. Child and adult physical activity

The ActiGraph wGT9x is an accelerometer-based device that will be secured to an elastic belt that is placed around the participant's waist with the device positioned on the right hip at the

anterior axillary line. The wGT9x will be initialized to collect raw data at 90Hz. The child and adult caregiver will be instructed to wear the accelerometer during all waking hours, except during water activities. At minimum, the child and adult caregiver must wear the wGT9x for 10 hours/d on at least 4 days, with at least one day being a weekend day. The raw wGT9x data will be used to estimate time spent in MVPA (physical activity at ≥ 3.0 metabolic equivalents units) using publicly available algorithms developed for youth [46] and adults [47]. All accelerometer data will be cleaned [48, 49] and processed [50] in R.

3.3.5 Meal planning, preparation, and grocery shopping

A 9-item questionnaire assessing parent time scarcity and fatigue as barriers to planning and preparing meals will measure frequency of occurrence of these barriers in adult caregivers. The 9-items have a 5-point scale to assess frequency of occurrence of barriers in the past 2 weeks [51]. Scores for this measure are summed to create an overall score for meal planning and preparation. Higher scores indicate greater frequency of occurrence of barriers in the past 2 weeks. Eight additional questions will assess occurrence of meal planning and grocery shopping in adult caregivers [52]. These questions ask how frequently the caregiver plans meals, the amount of time spent planning meals, and grocery shopping behaviors (i.e. using a list, use of a meal plan when making a list, and time spent grocery shopping).

3.3.6. Child eating pathology

The Kid's Eating Disorder Survey (KEDS), is a 14-item questionnaire that has demonstrated acceptable test-retest reliability and has been validated in children aged 13 and younger, will be used to assess eating pathology. Scores > 16 are considered elevated. The KEDS contains weight dissatisfaction and purging/restricting subscales. Children with elevated scores (> 16) at baseline will require primary care provider consent to participate in the trial [53].

In following assessments, children with elevated KEDS scores (> 16) will be referred to their primary care provider for further evaluation.

3.3.7. Home food inventory

The Home Food Inventory is a self-report inventory of different types of food in the home [54]. The inventory assesses home availability of fruits, vegetables, dairy products, frozen and prepared desserts, savory snacks, added fats, sugar-sweetened beverages, processed meats, high-fat microwavable foods, and candy. Participants mark yes or no if a listed food item is available in the home. For the categories of frozen desserts; microwavable or quick-cook frozen foods; prepared desserts; chips, crackers, and other snack foods; and candy, additional questions will ask families to list the number of different flavors/types of these foods. Inventory questions with yes/no responses are summed to create an overall food availability score, with a higher score indicating greater food availability. A sub-score for obesogenic home food availability is generated by summing the availability of the following: regular-fat versions of cheese, milk, yogurt, other dairy, frozen desserts, prepared desserts, savory snacks, added fats; regular-sugar beverages; processed meat; high-fat quick, microwavable foods; candy; and access to unhealthy foods in refrigerator and kitchen. For this sub-score, a higher score indicates higher obesogenic home food availability.

3.3.8. Child and adult sleep habits

Child and adult caregiver self-reported usual sleeping and waking behaviors over the previous 2 weeks will be collected. The following questions will be asked for school (work) and weekend nights separately: 1) usual total sleep time ("Figure out how long you usually sleep on a school night and fill it in here," answered as specific hours and minutes such as 7 hours, 30 minutes); 2) usual bedtime ("What time do you usually go to bed on school days?" answered as

one specific time, such as 11:30 p.m.); and 3) usual wake time ("What time do you usually wake up on school days?" answered as one time, such as 6:10 a.m.) [55].

3.3.9. Child routines

The Child Routines Inventory (CRI), an empirically derived, content-valid, parent-report measure of commonly occurring routines in school-aged children will measure the frequency of occurrence of routines in children. This questionnaire has 36 items and asks for frequency of occurrence of the items over the past month, using a 5-point Likert scale with end-points of "almost never" and "nearly always" [56]. Responses are summed to generate a total score; higher CRI scores indicate greater regularity in the child's routine.

3.3.10. Compliance and process data

As self-monitoring has been shown to be predictive of weight loss [57, 58], total number of weekly, and type of self-monitoring records (hard copy or electronic) completed will be assessed. Number of treatment sessions attended will be recorded [59, 60]. At follow-up assessments, participants will report on medications used; and participation in any additional diet, activity, or weight loss intervention program.

3.4. Treatment Fidelity

Treatment manuals based on protocols used by the team in the pilot study [17] will be developed. Interventionists will follow a session protocol based upon the treatment manuals. All sessions will be audiotaped and 33% of these sessions will be assessed for treatment fidelity. This will include a checklist of delivery of intervention components for each session (e.g., dietary goals, physical activity goals, behavioral parenting strategies) and fidelity to FBT and FBT+Variety (to address issues of potential contamination). Fidelity will be ascertained by

discussion of variety goals in FBT+Variety and lack of discussion regarding variety goals in FBT.

3.5. Power Analysis and Statistical Analysis Plan

To characterize change and to determine whether significant variability existed in participants' (both children and their caregiver) rates of change and initial values, a fixed and random effects approach to growth modeling will be used. All models will be estimated in MPlus version 8 [61]. The extent and pattern of missing data will be carefully examined and attrition effects will be evaluated by testing whether systematic differences exist between those who complete the research versus those who drop out. In instances when a small amount of data is missing from a measure (i.e., <10%) and relevant missing data correlates are included, data will be assumed to be missing at random, and a robust maximum likelihood estimator will be used (MLR) [62]. The MLR estimator adjusts standard errors and chi-squares/loglikelihoods to accommodate missing data, non-normal distributions, and nesting by clinicians and/or cohorts. Missing not at random models will also be estimated to determine whether the models are robust to the missing at random assumption of maximum likelihood estimation [62, 63]. Treatment differences by sex, race, and ethnicity will be included as covariate.

Because a non-linear relationship is anticipated between time and all outcomes (e.g. change from 0 to 6, 6 to 12 months, and 12 to 18 months followed either stability or a slight return toward baseline values), unconditional piecewise growth will be modeled using the following random parameters (along with their respective variances): intercept (reflecting individual differences in baseline values), slope 1 (reflecting individually varying rates of change during 0 to 6 months), slope 2 (reflecting individually varying rates of change from 6 to 12 months), and slope 3 (reflecting individually varying rates of change from 12 to 18 months).

Given the interest in change across the entire trial and 6 to 18 months, additional models will be estimated, in which the linear change from baseline to 18 months and 6 to 18 months will be modeled.

Although it is expected that randomization will equalize group characteristics, analyses will compare conditions on baseline characteristics (e.g., age, education), taking into account condition and wave. If differences occur, these variables will be covariates if related to the dependent variable of interest.

In order to determine the influence of FBT+Variety on long-term habituation to RED foods, analyses will use the growth modeling analyses as described in the overview, but will involve additional within-subjects source of variation from the two sets of stimuli in the habituation trials, and covariates of liking measures in the salivary habituation measure (controlling for differences in food liking between participants). To examine if habituation rate mediates the relationship between limited variety and changes in dietary intake and BMI, path analyses will be conducted, controlling for baseline BMI (or dietary variable), sex, race, and intervention group, using exported slopes and intercepts from the previous growth models.

In order to assess the influence of habituation rate on moderating outcomes in FBT+Variety and FBT, analyses will use the aforementioned growth modeling analyses, but will involve an additional between-subjects source of variation from the 0-month lemon juice salivary habituation measure that will classify participants as “slower” and “faster” habituators.

Sample size calculations presume 2-sided hypothesis testing at 18-month follow-up, with type one error rate (alpha) equal to 0.05. There will be 78 participants randomized to each condition, and all analyses will be conducted with the intent-to-treat principle. To reject with 80% power the null hypothesis of no treatment difference vs. the alternative that the treatment

difference is d = 0.51 or greater (projected effect size at 18-months based upon percent overweight differences and differences in energy from fat between the FBT and FBT+Variety conditions at 6 months in our pilot work) [17], 62 children per condition are required. This provides 80% power to detect a difference of 0.23 ZBMI between conditions (considered clinically relevant), given a standard deviation of 0.46 at 18 months [24] as well as medium-sized single regression coefficients ($f^2 \approx 0.06$). The intervention with 78 participants per group to allow for 20% attrition at 18 months.

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