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Effects of the Dyadic FirstStep2Health Intervention on Parents' Behavior and Anthropometric Outcomes: A Cluster Randomized Trial

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Effects of the Dyadic FirstStep2Health Intervention on Parents' Behavior and Anthropometric Outcomes: A Cluster Randomized Trial

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Data Statement: Study data can be requested from the corresponding author.

Abstract

Objectives. The aim of this study was to examine the preliminary efficacy of the FirstStep2Health vs control among parents on improving parental knowledge, self-efficacy, parenting styles and practice, home environment, lifestyle behaviors, and anthropometric outcomes.

Design. A cluster randomized controlled trial with 10 Head Start daycare centers (ClinicalTrials.gov ID: NCT04164277) was conducted using computer-generated randomization.

Setting. U.S. Head Start daycare centers.

Participants. 95 parent-child dyads (53 intervention and 42 control).

Interventions. The 16-week, dyadic, FirstStep2Health intervention included: 1) a daycare-based child program on healthy mindful eating and physical activity, 2) child letters to parents to connect school learning with home practice, 3) social media-based parent program to assist parents to promote healthy eating and physical activity at home, 4) virtual group parent meetings via zoom on topics related to healthy eating and physical activity, and 5) weekly motivational messages (3 times/week) to increase parental motivation to build and sustain a healthy home environment.

Results. Compared to the control group, intervention parents had significant improvement in knowledge (nutrition Cohen's d=.86, physical activity [PA] d=.51), PA self-efficacy (d=.47), and feeding practices rooted in perceived parent weight (d=-.46). Moreover, the intervention significantly decreased parents' permissive parenting style (d=-.49), systolic blood pressure (BP, d=-1.11), and diastolic BP (d=-.58). Other improvements in nutrition and PA parental support (d=.21, .25), home environment (d=.19, .21), and body mass index (BMI, d=-.34) are noteworthy.

Conclusions. Future endeavors to proactively engage parents in a dyadic childhood obesity prevention approach such as the FirstStep2Health intervention are warranted.

Keywords: Family; dyad; obesity; lifestyle; intervention

Strengths and limitations of this study

- The study is a cluster randomized controlled trial to account for cluster effects of daycare centers and classrooms.
- The study applied objective measurements including height, weight, percent body fat, blood pressure, and skin carotenoids.
- The study sample is ethnically and racially diverse with low-socioeconomic status.
- The study occurred under a global pandemic context, limiting the generalizability.
- The study had a relatively small sample size (n=95 Head Start parents) with 91.6% being female.

Introduction

Parents play a significant role in shaping children's overall health behaviors (Kao et al., 2020; Kao et al., 2019). Explicitly, childhood obesity experts stress the importance of implementing obesity prevention strategies with parents during the developing preschool years, as compared to the later stages of childhood development, because parental cognitions, attitudes, and behaviors contribute greatly to young children's lifestyles and weight status (Skouteris et al., 2011). Despite the significance, there are relatively few effective obesity prevention interventions targeting the parents of children living in poverty. Furthermore, parent-child dyadic approaches are suggested to be favorable in terms of improving both children and their parents' physical activity (PA) and diet quality (Sigmundová et al., 2020); however, the benefits that parents receive in such interventions remain relatively obscure. Therefore, the purpose of this study was to evaluate the preliminary efficacy of a dyadic school- and home-based healthy lifestyle intervention named FirstStep2Health on improving parents' outcomes including: moderate to vigorous PA (MVPA, primary outcome), diet quality (i.e., fruits/vegetables [F/V], fiber), screen time, proportion of overweight/obesity, body mass index (BMI), % body fat, blood pressure (BP), knowledge, self-efficacy, parental support, parenting style, feeding practices, and home environment.

The dyadic FirstStep2Health intervention

The plausibility of using a dyadic approach to include parents in childhood obesity prevention interventions was established a few decades ago (Skouteris et al., 2011). The growing application of the Actor-Partner Interdependence Model to promote dyads' healthy lifestyles (↑PA and healthy diet) have further endorsed the reciprocal influences between a parent and child within the family context (Fowler et al., 2021; Wiseman et al., 2018). Thus, parent cognitions/beliefs, behaviors, and parenting style/practice/efficacy are closely tied with children's eating and PA as well as weight-related outcomes. Most dyadic interventions have focused on evaluating effects on improving parents' knowledge regarding PA, nutrition, and feeding practices, but not their lifestyle behaviors or anthropometric changes (Skouteris et al., 2011). Consequently, thoroughly assessing the impact of our dyadic FirstStep2Health intervention on parental outcomes, especially lifestyle behaviors and anthropometrics (BMI, % body fat), is essential.

Mitigating familial obesogenic risk factors

Many familial obesogenic risk factors including inadequate PA, unhealthy eating behaviors, poor parent-child relationships, and exposure to an obesogenic environment contribute to childhood overweight or obesity (Blewitt et al., 2016). Obesity is a family problem because the family (particularly parents) is one of the most important influences on children's eating and PA choices (Hong et al., 2011). In a recent meta-analysis with 23 studies (Lee et al., 2022), the pooled odds ratio (OR) between parents' and children's overweight or obesity rate was 1.97 (95%CI=1.85-2.10). This adverse association can be due to a shared obesogenic environment (Mei et al., 2021) that is highly conducive to unhealthy lifestyles (↑screen time, ↓MVPA, ↓F/V, and ↓fiber) for both parents and children. Thus, to eliminate childhood obesity within a family context, it is essential for obesity prevention interventions to focus on cultivating a healthy home environment to promote healthy eating and regular PA. Moreover, parents need adequate knowledg and skills on how to promote and support their children to engage in healthy lifestyles (Risica et al., 2019). Undoubtedly, parents also need to utilize effective parenting practices to incorporate healthy foods and regular PA into their daily routine at home (Kao et al., 2019). Building on this evidence, our FirstStep2Health intervention targeted parents' knowledge, self-efficacy, and support to improve their parenting style, feeding practices and capabilities to build a nurturing and healthy home enviornment.

Improving anthropometric and cardiovascular outcomes

Children of parents with overweight or obesity are more likely to become overweight or obese during childhood or later in adulthood (Lee et al., 2022). Especially before age 12, children's trajectories to become overweight or obese are largely influenced by their parents' weight status (Nielsen et al., 2022). With a high proportion of U.S. adults suffering from overweight (30.7%) or obesity (42.4%) (Nielsen et al., 2022), children nowadays are at an increased risk of becoming overweight or obesity without effective parent-involved interventions. Undoubtedly, evaluating intervention effects on parents' anthropometric outcomes is essential to help prevent obesity-related morbidities not only in parents but also in their children over time. In this dyadic intervention, both BMI and % body fat were assessed because % body fat is a better predictor of cardiovascular risk as compared to BMI alone (Zeng et al., 2012). Similarly, systolic/diastolic BP are good indicators of parents' cardiovascular health (Wright et al., 2015).

Methods

Study Design, Setting, and Sample

This cluster randomized controlled trial was conducted with 10 Head Start daycare centers from the Midwestern US in fall 2021 to spring 2023. The study statistician randomly assigned the 10 centers into intervention or control groups using computer-generated random numbers. The study was approved by the local university institutional review board (STUDY00001629) and registered in ClinicalTrials.gov (NCT04164277).

We mainly used recruitment flyers to recruit participants. Classroom teachers helped to distribute the study recruitment flyers to families. Interested families were instructed to use the survey link or QR code on the flyer to complete the screening and enrollment survey and contact the study team with any questions. A face-to-face recruitment method was also used. The trained recruitment team went to each daycare center to recruit families during daycare drop-off and pick-up times. A $5 e-gift card was provided to each family who completed the screening and enrollment survey regardless of their participation status.

Inclusion criteria for parents included: 1) was the primary adult caregiver (parent or legal guardian ≥18 years old) for the Head Start children, 2) had at least weekly Internet access to use Facebook or the study private website to participate in designed intervention activities, and 3) could understand and speak English. Parents provided written consent for themselves as well as their children to participate in the study. In addition, children aged five years or older needed to provide verbal assent in order to be enrolled with their adult caregivers. Assuming a cluster effect intraclass correlation (ICC)=0.01, and significance level=.05, a sample size of 130 would provide a power of .80 to identify an effect size of 0.50.

Patient and Public Involvement

Patients or the public were not involved in the design, conduct, reporting, or dissemination plans of our research.

FirstStep2Health Intervention

Grounded in the Actor-Partner Interdependence Model and the Social Cognitive Theory (SCT), the 16-week, dyadic, FirstStep2Health intervention included: 1) a daycare-based child program on healthy mindful eating and physical activity, 2) child letters to parents to connect school learning with home practice, 3) social media-based parent program to assist parents to promote healthy eating and physical activity at home, 4) virtual group parent meetings via zoom on topics related to healthy eating and physical activity, and 5) weekly motivational messages (3 times/week) to increase parental motivation to build and sustain a healthy home environment. To promote mindful eating and regular physical activity at home, each intervention family received a healthy cookbook, adult and child MyPlate plates, and a community resource booklet. Table 1 provides details of the intervention.

The usual care control group did not receive any intervention during the study period. After post-intervention data collection, a 2-week mini program was offered. The control families received the same materials and supplies as the intervention families during the 2-week mini-program period, and control children participated in a 2-week daycare-based child program.

Data Collection

We collected outcome data at baseline before intervention start and immediately post-intervention. At each time point, parents received a survey link via text message or email to complete an online survey via Qualtrics. Then, a face-to-face appointment was scheduled to complete the measurements of height, weight, % body fat, and BP and distribute ActiGraph GT3X-plus accelerometers to assess PA. The face-to-face data collection appointment occurred in either a private daycare classroom or university conference room. Trained and blinded from randomization status, data collectors collected data from participants.

Measures

Parents completed reliable and valid instruments in an online survey measuring their demographics, F/V and fiber intake, screen time in hours per day, nutrition and PA knowledge, self-efficacy, support, parenting style, feeding practices, and home eating and PA environment were using reliable and valid instruments (see Table 2).

PA was measured using the ActiGraph GT3X-plus accelerometer with the wrist-worn approach (Phillips et al., 2021). ActiLife software was used to initialize each ActiGraph and set it to begin data collection at 5AM on the first day. We instructed parents to wear the ActiGraph on their dominant wrist (attached to an adjustable woven nylon wristband) from the time getting out of bed in AM to going to sleep at night for seven consecutive days (not worn bathing/swimming). An auto text message reminder was sent to parents every morning at 7AM via our developed HIPAA compliant platform Twilio (www.twilio.com). Parents' PA was reported as: sedentary 0-99, light 100-2019, moderate 2020-5998, and vigorous ≥5999 CPM (Troiano et al., 2008). Data were determined valid when wear time by the parents was at least eight hours per day for at least two days (Matthews, Ainsworth, Thompson, & Bassett, 2002; Penpraze et al., 2006).

Height and weight were measured by the ShorrBoard® Stadiometer to the nearest 0.1 cm and Seca model 874 scale to the nearest 0.01 kg, respectively. We used the BC-533 InnerScan Body Composition Monitor to measure parents' % body fat. During the measurements, parents were asked to take off shoes, socks, or bulky clothes. For measuring % body fat, each parent stepped onto the scale surface and aligned feet with the four electrodes.

Parents' BP was measured by the Omron HEM-705-CP digital blood pressure monitor following the protocol established by the American Heart Association (O'Brien et al., 1996). The day before data collection, parents were informed to not smoke, exercise, or injest caffeine during the 30 minutes before their BP was taken. During BP measurement, parents were instructed to keep their left arm on the measurement table (right arm was used if the left arm had a surgery or injury), sit upright, back straight, with feet flat on the floor.

To increase measurement reliability and validity, two measurements were taken for height, weight, % body fat, and BP. A third measurement would be taken, when the two measurements differed by ≥0.5 cm for height, ≥0.5 kg for weight, ≥1% for % body fat, and ≥5 mmHg for BP. To calculate the final measurment value, the two closest measurements were averaged.

Data Analysis

IBM SPSS Statistics 27 was used for all data analyses following the intention-to-treat principle. Statistically significant level was set at .05. Means, standard deviations, ranges, frequencies, and percentages were calculated to describe study variables. Independent t-tests or chi-square tests were applied to compare group differences in demographics. Mixed-effect models with restricted maximum likelihood estimation method were applied to examine intervention effects. In the mixed-effect models, post-intervention outcome was the dependent variable, fixed effect independent variable was group (intervention vs. control), and covariate was baseline outcome. Random cluster effects included both daycare center and classrooms, as parents' children were nested in daycare centers and classrooms. Further, when the dependent variable was the proportion of overweight/obesity, generalized linear mixed-effect model with logic link was performed to examine the group differences at post-intervention after controlling for baseline weight status and cluster random effects. The advantage of using mixed-effect models is that correct inference can be estimated even when missing data exist (Schafer & Graham, 2002). Effect sizes of Cohen's *d* and OR were calculated to describe the intervention effects: small (*d*=0.2, *OR*=1.68), medium (*d*=0.5, *OR*=3.47), and large (*d*=0.8, *OR*=6.71) (Chen et al., 2010; Fritz et al., 2012).

Results

Participants

A total of 95 parents (53 intervention and 42 control) participated in the study. Parents' mean age was 30.42 years old, and majority (91.6%) were female. About 8.4% were Hispanic and 36.8% were Black. Over half of the parents were single, and 66.3% of the families had an annual family income <$20,000. Nearly half of the parents were unemployed, and 57.9% had an education level of high school or less. On average, each family had three children living in the household. As shown in Table 3, parents' demographics are very comparable between the intervention and control groups.

Intervention Effects on Parents

As presented in Table 4, the intervention had medium to large effects on increasing parents' nutrition knowledge (d=.86; *95%CI*=.44, 1.29) and PA knowledge (d=.51; *95%CI*=.10, .92), and decreasing their systolic BP (d=-1.11; *95%CI*=-1.54, -.67) and diastolic BP (d=-.58; *95%CI*=-.99, -.17). The effects on increasing nutrition self-efficacy (d=.37; *95%CI*=-.04, .78), PA self-efficacy (d=.47; *95%CI*=.06, .88), and parental support on healthy eating (d=.21; *95%CI*=-.19, .62) and PA (d=.25; *95%CI*=-.16, .66) were small. Small effects were also observed on decreasing perceived parental weight (d=-.46; *95%CI*=-.87, -.05), parental monitoring on child's eating (d=-.39; *95%CI*=-.80, .02), authoritarian (d=-.30; *95%CI*=-.70, .11) and permissive (d=-.49; *95%CI*=-.90, -.08) parenting style, and BMI (d=-.34; *95%CI*=-.74, .07).

Table 5 demonstrates the results from mixed-effect models. Compared to the control group, parents in the intervention group had significantly higher nutrition knowledge (B=.87, p=.009), PA knowledge (B=.95, p=.049), nutrition self-efficacy (B=.74, p=.025), and PA self-efficacy (B=.86, p=.013) at post-intervention. In addition, fiber intake among intervention parents was significantly higher than control parents (B=2.99, p=.049). After the intervention, parents in the intervention group had significantly lower % body fat (B=-2.56, p=.005) and systolic BP (B=-10.98, p=.005) than those in the control group. Although not statistically significant, the intervention showed positive effects on improving parents' F/V intake, parental support on healthy eating and PA, home PA environment, and authoritative parenting style.

Discussion

The goal of this study was to examine the preliminary efficacy of FirstStep2Health vs control among parents in mitigating familial obesogenic risk factors (parental knowledge, lifestyles, parenting style/practice, and environment) and their anthropometric changes (BMI, % body fat, and BP). Overall speaking, the FirstStep2Health intervention significantly mitigated many familial obesogenic risk factors particularly with regards to parental knowledge and self-efficacy in promoting PA and healthy eating behaviors. These significant improvements in parental knowledge (nutrition and PA) and self-efficacy (nutrition) are congruent with previous studies (Skouteris et al., 2011). Although not statistically significant, the positive increases in parental support and home environment (d=.19-.25) among intervention parents are meaningful because building a supportive home environment that is more conducive for healthy eating and PA is an essential first step to prevent childhood obesity (Drewnowski et al., 2020).

Parental beliefs, attitudes, and practices regarding child feeding within the context of their children's obesity proneness improved among the intervention group. Most importantly, intervention parents' feeding practices were less likely to be influenced by their own perceived weight status (d=-.46), as compared to control parents. Although not statistically significant, the intervention group's parental control practices and attitudes regarding child feeding (restriction, pressure to eat, or monitoring) decreased (d=-.05 to -.39) over time. These positive results are encouraging as evidence indicates that parents' use of controlling restrictive feeding practices could result in negative effects on children's diet quality (Rollins et al., 2014).

The positive changes in intervention parents' feeding practices are also reflected in their improvements in parenting styles including increases in authoritative parenting and decreases in both authoritarian and permissive parenting. The significant decrease in utilizing permissive parenting style (d=-.49) among intervention parents is critical because permissive parenting was reported to contribute to children's various risky health behaviors include unhealthy lifestyles (Kao et al., 2019). Given that authoritative parenting is associated with a lower BMI in children (Sokol et al., 2017), promoting authoritative parenting can be an effective approach to prevent childhood obesity. Unfortunately, very few obesity prevention interventions have assessed the changes in parenting styles (Skouteris et al., 2011), limiting the comparison between this study's results on parenting styles and findings from previous literature. Regardless, the FirstStep2Health intervention's effects on enhancing positive parenting can help children to have not only a healthier lifestyle, but also better mental health which can subsequently lead to fewer behavioral problems (Delvecchio et al., 2020).

In terms of parents' lifestyle behavioral changes, intervention parents demonstrated positive changes in self-reported diet quality (↑F/V and ↑fiber intakes [d=.25 and .26, respectively]) but not the skin carotenoids level (d=-.25). The decreases in skin carotenoids level may have occurred because the control parents had a much lower level of skin carotenoids at baseline (236.83 vs. 256.33), as compared to intervention parents. Another reason is the potential existing of confounders, as skin carotenoids were reported to be associated with sex, BMI, race/ethnicity, smoking, and sun exposure (Madore et al., 2023). For the accelerometer-measured PA, both intervention and control parents experienced deceases in the study. The most plausible explanation for the unsuccessful result may be that the global pandemic has caused significant decreases in PA and increases in sedentary activity (Park et al., 2022).

Although parents in both groups experienced increases in their BMI and % body fat during the study, intervention parents had a smaller increase than control parents (*d*=-.34, -.32). In addition, intervention parents' % body fat was significantly lower than control parents at post-intervention after controlling for the baseline values. This result is noteworthy because % body fat is a stronger indicator of cardiovascular risks than BMI (Piché et al., 2018). More importantly, intervention parents had decreases in both systolic and diastolic BP, indicating a reduced risk for cardiovascular disease (Fuchs & Whelton, 2020). The critical role of active parental engagement in childhood healthy lifestyle interventions has been well established (Mehdizadeh et al., 2019), but limited evidence exists on the beneficial effects of these types of dyadic interventions on parents' anthropometrics. Although further investigations with a larger sample size are needed, the study's results show some favorable effects of a childhood healthy lifestyle intervention on parents' cardiovascular risk factors including % body fat and BP.

Limitations

This study has some limitations. First, this study had a relatively small sample size (n=95 Head Start parents) with 91.6% being female. Thus, generalizing to the general public or male caregiving adults would be inadvisable. Second, this study was conducted under a global COVID pandemic context. Because the potential additional stress that parents had encountered during the pandemic was not accounted for in the analysis, caution is needed when interpreting the results. Finally, we could not possibly control for every potential lifestyle factor, and the self-reported nature of some measurements leaves the possibility of residual confounding.

Conclusions

The positive impacts of the dyadic FirstStep2Health intervention on parents are promising. In addition to the improvements in parental knowledge and self-efficacy, the intervention's contributions to improving parenting styles and feeding practice as well as anthropometric and cardiovascular outcomes (↓BMI, ↓% body fat, ↓systolic BP and ↓diastolic BP) are vital given the detrimental impacts of obesity-related comorbidities (i.e., hypertension, type 2 diabetes, cardiovascular diseases, and cancers) in the US. Finally, our positive findings further endorse the future endeavors to proactively engage parents in childhood obesity prevention efforts.

Table 1. The dyadic FirstStep2Health intervention for parent-child dyads

Component	Purpose	Description
Daycare-based child program	Increase knowledge and skill on healthy eating and PA	Children received weekly, age-appropriate, participatory learning sessions delivered by trained interveners on mindful eating (learning/tasting fruits/vegetables using five senses) and physical activity (practicing fun animal movements and activity games including yoga stretching movements and relaxing breathing activities).
Child letters	Connect school learning with home practice	Each week, children created two letters using stickers regarding a food or activity presented in the daycare-based program that they liked or wanted to try at home. Letters were sent privately to each parent via Facebook messenger or text messaging every Wed. and Fri. Parents were encouraged to discuss letters with their children and offer foods and activities desired by children. Parents were also asked to answer two Facebook multiple-choice questions related to the letters each week by Sun. midnight (a. What foods listed in your child's letter did you provide? b. What activities listed in your child's letter did your family try?).
Social media-based parent program	Foster a healthier home environment	Provided parents a weekly electronically retrievable flyer containing health information, family fun activities, and behavioral change strategies to help create a healthier home environment and encouraged interactive positive communication to promote peer support. Parents were asked to post a message or a picture on healthy eating and physical activity, positively respond to other parents' postings, and complete a 2-question quiz each week to reinforce information and strategies learned in the weekly flyer.
Parent group meetings	Promote behavioral change strategies	Three virtual meetings via zoom at week 1, 8 and 16, each meeting lasted about an hour. **Meeting 1**: program orientation, heathy cooking. **Meeting 2**: MyPlate plates, food labels, smart shopping. **Meeting 3**: program overview, community healthy eating and PA resources (e.g., farmer's markets, community gardens, nearby parks or other free or affordable PA facilities).
Motivational text messages	Increase parental motivation	Every week, three motivational text messages were sent at noon on Monday, Wednesday, and Friday to focus on parenting/family and lifestyle changes. For example, "*If there is anything that we wish to change in our children, we should first examine it and see whether it is not something that could better be changed in ourselves*."

Table 2. Study measures

Concept	Measure	# Items	Reliability/Validity in Literature	Cronbach's a in this study
Screen time	NHANES-Physical Activity and Physical Fitness Survey (Centers for Disease Control and Prevention, 2017)	1	Reliability: *r*=0.63-0.84 (Sirard et al., 2013)	N/A
F/V and fiber intake	Fruit-Vegetable-Fiber Screener (Block et al., 2000)	10	*r*=0.71 with full Block survey (Block et al., 2000)	0.78
Knowledge	Knowledge On Preschoolers' Dietary Intake & Physical Activity (Horodynski et al., 2011)	25	N/A	N/A
Self-efficacy	Parental Self-Efficacy Scale (Horodynski et al., 2011)	20	a=0.72-0.75 (Horodynski et al., 2011)	0.95
Parental support	Parental Support Scale For Eating Habits And Physical Activity (Trost et al., 2003)	12	a=0.83-0.87 (Sallis et al., 1987)	0.84
Parenting style	Parenting Style and Dimensions Questionnaire (Robinson et al., 2001) has 3 subscales: authoritative, authoritarian, and permissive.	32	a=0.64-0.91 (Olivari et al., 2013)	0.82
Feeding practices	Child Feeding Questionnaire (Birch et al., 2001) includes 7 subscales: perceived responsibility for child feeding, perceived parent weight status, perceived child weight status, concerns about child weight, restrictions of child's access to food, pressure to ask child to eat more, and monitoring of child's eating.	33	a=0.71-0.93 *r*=-0.26-0.53 with child BMI (Corsini et al., 2008)	0.75
Home environment	Family Nutrition and Physical Activity screening tool (Ihmels, Welk, Eisenmann, & Nusser, 2009)	20	Correlated with child BMI (Ihmels, Welk, Eisenmann, Nusser, & Myers, 2009)	0.82

Table 3. Demographic characteristics of parents

Variable	Total (*N*=95)		Intervention (*n*=53)		Control (*n*=42)		t-test/Chi-square test	
	N (mean)	*% (SD)*	*N (mean)*	*% (SD)*	*N (mean)*	*% (SD)*	t/χ^2	p-value
Age (years, 21-48)	30.42	5.73	30.74	6.11	30.02	5.27	.60	.551
Sex (Female)							.81	1.0
Female	87	91.6	48	90.6	39	92.9		
Male	7	7.4	4	7.5	3	7.1		
Other	1	1.1	1	1.9	0	0		
Ethnicity (Hispanic)	8	8.4	3	5.7	5	11.9	1.19	.459
Race							8.59	.077
White	44	46.3	18	34	26	61.9		
Black	35	36.8	23	43.4	12	28.6		
Mixed race	9	9.5	6	11.3	3	7.1		
Other	7	7.4	6	11.3	1	2.4		
Marital status							1.78	.424
Married/partnered	36	37.9	23	43.4	13	31		
Separated/widowed	5	5.3	3	5.7	2	4.8		
Single	54	56.8	27	50.9	27	64.3		
Annual family income							6.13	.077
< $20,000	63	66.3	32	60.4	31	73.8		
$20,000-$29,999	15	15.8	8	15.1	7	16.7		
$30,000-$49,999	16	16.8	13	24.5	3	7.1		
≥ $50,000	1	1.1	0	0	1	2.4		
Employment status							.20	.929
Full-time	23	24.2	13	24.5	10	23.8		
Part-time	25	26.3	13	24.5	12	28.6		
No	47	49.5	27	50	20	47.6		
Education level							4.54	.313
< high school	15	15.8	9	17	6	14.3		
High school	40	42.1	22	41.5	18	42.9		
Some college	29	30.5	13	24.5	16	38.1		
Technical/community college	10	10.5	8	15.1	2	4.8		
Bachelor's degree	1	1.1	1	1.9	0	0		
Number of children							6.21	.527
1 child	18	19.2	10	18.9	8	19.5		
2 children	30	31.9	17	32.1	13	31.7		
3 children	22	23.4	13	24.5	9	22		
4 children	13	13.8	8	15.1	5	12.2		
≥ 5 children	11	11.7	5	9.4	6	14.6		
Missing	1	1.1	0	0	1	2.4		

Table 4. Descriptions of parents' outcomes over time

Outcome	Intervention				Control				Effect Sizes		
	Baseline		Post-Intervention		Baseline		Post-Intervention				
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	[a]*Cohen's d*	*LL*	*UL*
Psychosocial Outcomes											
Nutrition knowledge	6.72	1.34	7.45	1.27	7.24	1.46	6.68	1.87	**.86**	.44	1.29
PA knowledge	12.02	1.50	12.53	1.64	12.19	1.73	11.58	2.42	**.51**	.10	.92
Nutrition self-efficacy	8.36	1.51	8.95	1.35	8.16	1.55	8.18	1.68	.37	-.04	.78
PA self-efficacy	8.59	1.58	9.27	1.12	8.56	1.33	8.38	1.70	**.47**	.06	.88
Nutrition parental support	4.12	.91	4.52	.80	4.17	.98	4.39	.71	.21	-.19	.62
PA parental support	4.71	1.26	5.15	1.05	4.55	.96	4.64	1.25	.25	-.16	.66
Parenting style											
Authoritative	4.20	.48	4.35	.52	4.02	.72	4.0	.76	.27	-.14	.67
Authoritarian	1.64	.48	2.46	1.24	1.63	.45	2.78	.91	-.30	-.70	.11
Permissive	2.40	.80	2.16	.84	2.26	.69	2.41	.88	**-.49**	-.90	-.08
Parent feeding practices											
Feeding responsibility	4.67	.52	4.65	.71	4.59	.66	4.58	.64	-.01	-.87	.39
Perceived parent weight	3.14	.36	3.11	.43	3.15	.41	3.31	.46	**-.46**	-.87	-.05
Perceived child weight	2.97	.29	2.95	.32	2.93	.25	2.88	.29	.11	-.30	.52
Concern about child weight	1.46	.82	1.46	1.05	1.20	.31	1.13	.26	.09	-.32	.50
Restriction	3.54	.74	3.33	.86	3.54	.74	3.37	.87	-.05	-.46	.35
Pressure to eat	3.13	1.0	2.86	.99	2.79	.84	2.68	.80	-.16	-.56	.25
Monitoring	4.21	.82	4.04	1.10	3.82	1.21	4.13	.83	-.39	-.80	.02
Home eating environment	30.94	4.24	31.68	4.13	30.74	3.52	30.74	4.07	.19	-.22	.59
Home PA environment	30.52	5.07	31.24	4.78	28.74	4.59	28.42	4.71	.21	-.19	.62
Behavioral Outcomes											
PA											
Light (min/hour)	17.89	3.77	15.72	9.19	19.03	8.27	14.43	9.17	.23	-.18	.63
MVPA (min/hour)	15.98	7.48	8.25	6.75	14.48	6.95	10.14	9.77	-.36	-.77	.05
Diet Quality											

F/V intake (servings/day)	3.39	1.93	4.52	2.46	2.95	2.03	3.44	1.58	.25	-.15	.66
Fiber intake (servings/day)	14.31	5.66	17.52	7.26	12.69	5.93	14.03	5.12	.26	-.14	.67
#Skin carotenoids	256.33	55.88	252.63	41.61	236.83	50.14	250	44.2[illegible]	-.25	-.65	.16
Screen time (hours/day)	6.40	5.29	4.93	4.71	7.38	6.18	5.93	5.67	-.003	-.41	.40
Physical Outcomes											
BMI	29.55	8.32	31.3	8.37	32.43	9.51	33.58	8.91	-.34	-.74	.07
% body fat	36.07	9.01	37.42	6.58	39.28	10.85	41.8	8.3	-.32	-.73	.09
Systolic BP	122.53	18.69	120.98	21.12	117.05	9.02	129	17.2[illegible]	**-1.11**	-1.54	-.67
Diastolic BP	75.14	13.39	77	14.88	75.98	6.49	82.44	9.41	**-.58**	-.99	-.17
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*^{b}OR*	*LL*	*UL*
Proportion of OW/B	23	69.7	23	79.3	13	61.9	16	80	.96	.23	3.95

Note. [a]Cohen's d was calculated using mean difference and the standard deviation of the mean difference in each group (Borenstein, Hedges, Higgins, & Rothstein, 2021) and positive values indicate the intervention group had a mean increase from baseline to post-intervention when comparing to the control group. [b]OR was calculated using the post-intervention OW/O rate in each group. #Skin carotenoids were measured only in the study Year 2 among 38 parents using Veggie Meter; SD=standard deviation; BMI=body mass index; F/V=fruits/vegetables; PA=physical activity; MVPA=moderate to vigorous physical activity; OW/O=overweight/obesity; OR=odds ratio; LL=lower limit; UL=upper limit.

Table 5. Intervention effects on parents' outcomes

Outcome	*B*	*95% CI for B*	*p-value*
Psychosocial Outcomes			
Nutrition knowledge	.87	.23, 1.52	**.009***
PA knowledge	.95	.002, 1.89	**.049***
Nutrition self-efficacy	.74	.09, 1.39	**.025***
PA self-efficacy	.86	.19, 1.53	**.013***
Nutrition parental support	.27	-.05, .58	.099
PA parental support	.53	-.01, 1.07	.055
Parenting style			
Authoritative	.27	-.01, .55	.060
Authoritarian	-.28	-.81, .25	.292
Permissive	-.27	-.62, .09	.139
Parent feeding practices			
Feeding responsibility	.06	-.27, .40	.702
Perceived parent weight	-.17	-.35, .02	.081
Perceived child weight	.04	-.08, .17	.502
Concern about child weight	.22	-.14, .58	.233
Restriction	-.03	-.38, .33	.879
Pressure to eat	.13	-.28, .55	.526
Monitoring	-.18	-.67, .30	.448
Home eating environment	.67	-1.04, 2.38	.439
Home PA environment	1.91	-.19, 4	.073
Proximal Behavioral Changes			
PA			
Light (min/hour)	4.06	-3.98, 12.10	.308
MVPA (min/hour)	.49	-5.82, 6.81	.874
Diet Quality			
F/V intake	1.0	-.01, 2.01	.051
Fiber	2.99	.02, 5.97	**.049***
#Skin carotenoids	32.16	-40.41, 104.72	.330
Screen time (hours/day)	-.84	-3.38, 1.70	.512
Distal Anthropometric Outcomes			
BMI	-.77	-1.94, .40	.191
% body fat	-2.56	-4.29, -.84	**.005***
Systolic BP	-10.98	-18.31, -3.64	**.005***
Diastolic BP	-2.78	-8.86, 3.31	.360
	OR	***95% CI for OR***	***p-value***
Proportion of OW/B	1.77	.04, 87.5	.769

Note. *$p \leq .05$; #Skin carotenoids were measured in the study Year 2 among 38 parents using Veggie Meter; SD=standard deviation; BMI=body mass index; F/V=fruits/vegetables; PA=physical activity; MVPA=moderate to vigorous physical activity; OW/O=overweight/obesity; OR=odds ratio.

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Effects of the Dyadic FirstStep2Health Intervention on Parents' Behavior and Anthropometric Outcomes: A Cluster Randomized Trial

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Effects of the Dyadic FirstStep2Health Intervention on Parents' Behavior and Anthropometric Outcomes: A Cluster Randomized Trial

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Author Statement: JL contributed to the study design and conduction, drafted the paper, and was the Principal Investigator of the study. TAK contributed to data interpretation, drafted the paper, and critically edited drafts. LBR and JMK contributed to the conceptualization, edited drafts, and were co-investigators of the study. NZ contributed to data analysis, edited drafts, and was a co-investigator of the study. YS developed the program private website and text messaging programs, critically reviewed the paper, and was a consultant of the study. All authors approved the final version of the manuscript.

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Abstract

Objectives. This study aimed to examine the preliminary efficacy of the FirstStep2Health vs usual care control on improving parents' lifestyle behaviors (moderate to vigorous physical activity [primary outcome], screen time, fruit/vegetable and fiber intake, skin carotenoids), nutrition and physical activity knowledge, self-efficacy, support, parenting style, feeding practices, home environment, anthropometric outcomes (body mass index, percent body fat), and blood pressure from baseline to post-intervention after adjusting for random cluster effects.

Design. A cluster randomized controlled trial with 10 Head Start daycare centers (ClinicalTrials.gov ID: NCT04164277; 5 intervention, 5 control) was conducted using computer-generated randomization after baseline data collection.

Setting. U.S. Head Start daycare centers.

Participants. 95 parent-child dyads (53 intervention, 42 control).

Interventions. The 16-week, dyadic, FirstStep2Health intervention included: 1) a daycare-based child program on healthy mindful eating and physical activity, 2) child letters to parents to connect school learning with home practice, 3) social media-based parent program to assist parents to promote healthy eating and physical activity at home, 4) virtual group parent meetings via Zoom on topics related to healthy eating and physical activity, and 5) weekly motivational messages to increase parental motivation to build a healthy home environment.

Results. Compared to the control group, intervention parents had significant improvement in knowledge (nutrition Cohen's *d*=.86, *95%CI*: .44, 1.29; physical activity *d*=.51, *95%CI*: .10, .92), physical activity self-efficacy (*d*=.47, *95%CI*: .06, .88), and feeding practices rooted in perceived parent weight (*d*=-.46, *95%CI*: -.87, -.05) from baseline to post-intervention. Moreover, the intervention significantly decreased parents' permissive parenting style (*d*=-.49, *95%CI*: -.90, -.08), systolic blood pressure (*d*=-1.11, *95%CI*: -1.54, -.67), and diastolic blood pressure (*d*=-.58, *95%CI*: -.99, -.17). Other non-statistically significant improvements in nutrition and physical activity parental support (*d*=.21, .25), home environment (*d*=.19, .21), and body mass index (*d*=-.34) are noteworthy.

Conclusions. Future endeavors to proactively engage parents in a dyadic childhood obesity prevention approach such as the FirstStep2Health intervention are warranted to improve outcomes among both children and parents.

Keywords: FirstStep2Health intervention; obesity prevention; obesogenic risk factors; parent-child dyads

Strengths and limitations of this study

- The study is a cluster randomized controlled trial to account for cluster effects of daycare centers and classrooms.
- The study applied objective measurements including height, weight, percent body fat, blood pressure, and skin carotenoids.
- The study sample is ethnically and racially diverse with low-socioeconomic status.
- The study occurred under a global pandemic context, limiting the generalizability.
- The study had a relatively small sample size (n=95 Head Start parents) with 91.6% being female.

Introduction

Parents play a significant role in shaping children's overall health behaviors (1, 2). Explicitly, childhood obesity experts stress the importance of implementing obesity prevention strategies with parents during the developing preschool years, as compared to the later stages of childhood development, because parental cognitions, attitudes, and behaviors contribute greatly to young children's lifestyles and weight status (3). In fact, children of parents with overweight or obesity are more likely to have similar concerns during childhood or later in adulthood (4). Especially before age 12, children's trajectories for developing overweight or obesity are largely influenced by their parents' weight status (5). In a recent meta-analysis with 23 studies (4), the pooled odds ratio (OR) between parents' and children's overweight or obesity rate was 1.97 (95%CI=1.85-2.10).

With a high proportion of United States (U.S.) adults suffering from overweight (30.7%) or obesity (42.4%) (5), children nowadays are at an increased risk of developing overweight or obesity without timely and effective parent-involved interventions. Compared to child- or parent-only interventions (6), targeting parent-child dyads simultaneously was highly recommended because dyadic interventions have demonstrated greater and longer sustaining effects on reducing children' body mass index (BMI) (7). Despite the significance, there are relatively few effective obesity prevention interventions targeting young children and their parents living in poverty (8). Furthermore, actively engaging parents in childhood obesity prevention interventions is suggested to be favorable in terms of improving children's physical activity and diet quality (9). However, the benefits that parents receive in such dyadic interventions remain relatively obscure (10).

Obesity is a family problem because the family (particularly parents) is one of the most important influences on children's eating and physical activity choices (1). Although many familial factors (i.e., shared genetic material, inherited predisposition, and shared obesogenic environment) contribute to childhood obesity, focusing on the shared obesogenic environment that account for the strong intergenerational transmission of obesity is logical (11, 12). This is because environmental risks are modifiable, whereas the spread of new mutations or polymorphisms takes a long time. The shared obesogenic environment is usually highly conducive to unhealthy lifestyles (↑screen time, ↓physical activity, ↓fruits/vegetables [F/V], and ↓fiber) among both parents and children (13). Thus, to eliminate childhood obesity within a family context, it is essential for developing dyadic obesity prevention interventions to focus on cultivating a healthy home environment to promote healthy eating and regular physical activity.

Most previous dyadic interventions have focused on evaluating effects on improving parents' knowledge regarding physical activity, nutrition, and feeding practices, but not their lifestyle behaviors or anthropometric changes (3). Since the literature has confirmed that parents' and children's lifestyles and anthropometrics are highly correlated (4, 14). Thoroughly understanding the impact of dyadic interventions on parental outcomes, especially lifestyle behaviors and anthropometrics (BMI, % body fat) is crucial because it can serve as an essential step in mitigating obesity-related comorbidities from a family perspective. In addition, knowing the benefits of dyadic intervention on both parties' outcomes is valuable as it highlights the reciprocal influences between parent and children (2). This understanding can lead to the development of more effective strategies for improving family health, fostering supportive home environments, and promoting positive behavior changes within the entire family system. Given that % body fat is a better predictor of cardiovascular risk compared to BMI (15), and that systolic/diastolic blood pressure (BP) are good indicators of cardiovascular health (16), evaluating these outcomes in parents is fundamental for developing evidence to improve their cardiovascular health. Therefore, the purpose of this study was to evaluate the preliminary efficacy of a dyadic school- and home-based healthy lifestyle intervention named FirstStep2Health on improving parents' 1) primary outcome of moderate to vigorous physical activity (MVPA) and 2) secondary outcomes of diet quality (i.e., F/V and fiber intake, skin carotenoids), screen time, proportion of overweight/obesity, BMI, % body fat, BP, nutrition and physical activity knowledge, self-efficacy, parental support, parenting style, feeding practices, and home environment after adjusting for random cluster effects.

Methods

Conceptual Framework

The intervention development was grounded in both the Actor-Partner Interdependence Model and the Social Cognitive Theory (17, 18). The Actor-Partner Interdependence Model endorses the reciprocal influences between a parent and a child within the family context (19, 20). Based on the Social Cognitive Theory, individuals' behaviors can be modified by their knowledge, self-efficacy, social support, and environment. Parents require sufficient knowledge and self-efficacy to effectively promote and support their children in adopting healthy lifestyles (21). Additionally, they need to employ effective parenting practices to integrate healthy foods and regular physical activity into their daily family routines (22). Building on these theories and evidence, our FirstStep2Health dyadic intervention targeted parents to enhance their knowledge, self-efficacy, and support to improve their parenting style and feeding practices, fostering a nurturing and healthy home enviornment. To enhance the influences from children to parents, we implemennted an innovative approch that connected school learning with home practices to further promote healthy eating and physical activity behaviors at home.

Overview of the FirstStep2Health Study

This cluster randomized controlled trial was conducted with 10 Head Start daycare centers from the Midwestern U.S. in fall 2021 to spring 2023. A cluster randomized controlled trial was used to minimize contamination because children are clustered within daycare classrooms and centers. The intervention period was November to March in each year. The intervention effects on improving children's outcomes (Primary Aim of the trial) were published in a prior manuscript (23) and this current manuscript focused on examining the effects on parents' outcomes (Secondary Aim). The study statistician randomly assigned the 10 centers into intervention (5 centers) or control (5 centers) groups using computer-generated random numbers after participant enrollment and baseline data collection. The study was approved by the local university Biomedical and Health Institutional Review Board (STUDY00001629) and registered in ClinicalTrials.gov (NCT04164277).

We mainly used recruitment flyers to recruit participants. Classroom teachers helped to distribute the study recruitment flyers to families. Interested families were instructed to use the survey link or QR code on the flyer to complete the screening and enrollment survey and contact the study team with any questions. A face-to-face recruitment method was also used. The trained recruitment team went to each daycare center to recruit families during daycare drop-off and pick-up times. A $5 e-gift card was provided to each family who completed the screening and enrollment survey regardless of their participation status.

Head Start daycare centers serving children aged 3-5 years old were eligible to participate in the study. Inclusion criteria for parents included: 1) was the primary adult caregiver (parent or legal guardian ≥18 years old) for the Head Start children, 2) had at least weekly Internet access to use Facebook or the study private website to participate in designed intervention activities, and 3) could understand and speak English. Parents provided written consent for themselves as well as their children to participate in the study. In addition, children aged five years or older needed to provide verbal assent in order to be enrolled with their adult caregivers. All eligible and consented children and parents from participating daycare centers were enrolled in the study.

Assuming an overall cluster effect intraclass correlation coefficient (ICC)=0.01 based on prior literature (24), no variations between clusters, and significance level=.05, a sample size of 6 daycare centers, 24 classrooms, and 130 participants would provide a power of .80 to identify an effect size of 0.50 in the trial's primary outcome of children's MVPA (23). The selected effect size of 0.50 was based on the results observed in our previous quasi-experimental feasibility study (25).

Patient and Public Involvement

Patients or the public were not involved in the design, conduct, reporting, or dissemination plans of our research.

Intervention

The 16-week, dyadic, FirstStep2Health intervention was tailored to economically marginalized families with young children (23). We actively engaged Head Start teachers and parents to develop culturally appropriate content for the intervention through focus groups and interviews (25, 26). The intervention included: 1) a 16-week (total 32 sessions) daycare-based child program on healthy mindful eating and physical activity, tailored to young children's developmental stage; 2) 32 child letters to parents to connect school learning with home practice; 3) a 16-week social media-based parent program to assist parents to promote healthy eating and physical activity at home; 4) 3 virtual group parent meetings at week 1, 8, and 16 via Zoom on topics related to healthy eating and physical activity, we had to change the meeting delivery format from in-person to virtual Zoon sessions due to the COVID-19 pandemic; and 5) weekly motivational messages (3 times/week for 16 weeks) to increase parental motivation to build and sustain a healthy home environment. The daycare-based child program was delivered in-person by trained interventionists to all children enrolled in the intervention daycare centers instead of pulling only the study children out. This approach was highly recommended by Head Start administrators and can help reduce potential feelings of insecurity and anxiety among children. Make-up sessions were offered to ensure the full dose of 32 sessions was achieved when intervention classes were closed due to the spread of COVID-19 cases. To promote mindful eating and regular physical activity at home, each intervention family received a healthy cookbook containing budget-friendly family recipes, adult and child MyPlate plates to guide appropriate portion size, and a community resource booklet to help sustain healthy behavioral changes. Table 1 provides details of the intervention.

The usual care control group did not receive any intervention during the study period. After post-intervention data collection, a 2-week mini program was offered. The 2-week mini program included: 1) children received a 2-week daycare-based child program in daycares, 2) children completed two letters to parents to share what they had learned from the 2-week child program, and 3) parents received a program handbook containing all intervention instructions and flyers as well as supplies including a healthy cookbook, 2 MyPlate plates, and a community resource booklet.

Intervention implementation fidelity monitoring. To monitor the implementation fidelity of the child program, trained independent process evaluators observed six randomly selected sessions (two sessions at week 1-4, two sessions at week 7-10, and two sessions at week 13-16) at each intervention classroom. Feedback and suggestions were provided to the interventionists for further improvement. A remediation plan with additional training would be implemented if the total score was less than 4 out of a 6-point range. The project manager conducted three parent meetings following developed scripts to ensure consistent delivery. The study process evaluators observed each parent meeting to evaluate the delivery fidelity in comparison with the developed scripts.

Data Collection

We collected individual outcome data at baseline before intervention start and immediately post-intervention. At each time point, parents received a survey link via text message or email to complete an online survey via Qualtrics. Then, a face-to-face appointment was scheduled to complete the measurements of skin carotenoids, height, weight, % body fat, and BP; and distribute ActiGraph GT3X-plus accelerometers to assess physical activity. The face-to-face data collection appointment mainly occurred at a private daycare classroom within participating Head Start centers. However, we also offered home visiting data collection options for participants who were uncomfortable leaving home due to pandemic concerns. Some in-person data collection events were held at a local university conference room when a participating Head Start center was closed due to the spread of COVID-19 cases. Trained and blinded from randomization status, data collectors collected data from participants.

Measures

Parents completed reliable and valid instruments in an online survey measuring their demographics, F/V and fiber intake, screen time in hours per day, nutrition and physical activity knowledge, self-efficacy, support, parenting style, feeding practices, and home eating and physical activity environment (see Table 2). The primary outcome was MVPA, secondary outcomes were F/V and fiber intake, skin carotenoids, screen time, proportion of overweight/obesity, BMI, % body fat, BP, nutrition and physical activity knowledge, self-efficacy, parental support, parenting style, feeding practices, and home eating and physical activity environment.

Primary outcome MVPA was measured using the ActiGraph GT3X-plus accelerometer with the wrist-worn approach (27). ActiLife software was used to initialize each ActiGraph and set it to begin data collection at 5AM on the first day. We instructed parents to wear the ActiGraph on their dominant wrist (attached to an adjustable woven nylon wristband) from the time getting out of bed in AM to going to sleep at night for seven consecutive days (not worn bathing/swimming). An auto text message reminder was sent to parents every morning at 7AM via our developed HIPAA compliant platform Twilio (www.twilio.com). Parents' physical activity was reported as: sedentary 0-99, light 100-2019, moderate 2020-5998, and vigorous ≥5999 counts per minutes (28). Data were determined valid when wear time by the parents was at least eight hours per day for at least two days (29, 30).

Skin carotenoids were measured by the pressure-mediated reflection spectroscopy with the Veggie Meter (®Longevity Link Corporation). Skin carotenoids are being used as a non-invasive biological marker for F/V intake due to their consistent positive correlation with plasma/serum carotenoids in the adult population (31). Evidence has supported the sensitivity of using Veggie Meter to detect changes in skin carotenoids in experimental studies among ethnically/racially diverse populations (32).

Height and weight were measured by the Shortboards® Stadiometer to the nearest 0.1 cm and Seka model 874 scale to the nearest 0.01 kg, respectively. BMI was calculated using measured height and weight: weight (kg)/[height (m)]^2. We used the BC-533 InnerScan Body Composition Monitor to measure parents' % body fat. During the measurements, parents were asked to take off shoes, socks, or bulky clothes. For measuring % body fat, each parent stepped onto the scale surface and aligned feet with the four electrodes.

Parents' BP was measured by the Omron HEM-705-CP digital blood pressure monitor following the protocol established by the American Heart Association (33). The day before data collection, parents were informed to not smoke, exercise, or injest caffeine during the 30 minutes before their BP was taken. During BP measurement, parents were instructed to keep their left arm on the measurement table (right arm was used if the left arm had a surgery or injury), sit upright, back straight, with feet flat on the floor.

To increase measurement reliability and validity, two measurements were taken for height, weight, % body fat, and BP. A third measurement would be taken, when the two measurements differed by ≥0.5 cm for height, ≥0.5 kg for weight, ≥1% for % body fat, and ≥5 mmHg for BP. To calculate the final measurment value, the two closest measurements were averaged.

Data Analysis

IBM SPSS Statistics 27 was used for all data analyses following the intention-to-treat principle to preserve the original randomization. That is, data were analyzed based on participants' originally assigned group regardless of whether they received the intervention or not. Statistically significant level was set at .05. Because the study only had one primary outcome of MVPA, we did not adjust the significant level due to multiple comparisons. Means, standard deviations, ranges, frequencies, and percentages were calculated to describe study variables. Independent t-tests or chi-square tests were applied to compare group differences in individual demographics and identified significant demographics were adjusted in the further analyses. Mixed-effect models with restricted maximum likelihood estimation method and Satterthwaite approximations for degrees of freedom (34) were applied to examine intervention effects. In the mixed-effect models, post-intervention outcome was the dependent variable, fixed effect independent variable was group (intervention vs. control), and covariate was baseline outcome and any identified significant demographics. Random cluster effects included both daycare centers and classrooms, as parents' children were nested in daycare centers and classrooms. Further, when the dependent variable was the proportion of overweight/obesity, generalized linear mixed-effect model with logic link was performed to examine the group differences at post-intervention after controlling for baseline weight status and cluster random effects. The advantage of using mixed-effect models is that correct inference can be estimated even when missing data exist (35). Effect sizes of Cohen's *d* and OR were calculated to describe the intervention effects: small (*d*=0.2, *OR*=1.68), medium (*d*=0.5, *OR*=3.47), and large (*d*=0.8, *OR*=6.71) (36, 37).

Results

Participants

The study's flow diagram was published in a prior manuscript reporting the intervention effects on improving children's outcomes (23). No daycare center or classroom was lost to follow-up. The loss to follow-up rate among children was 10.5%, primarily due to children leaving Head Start daycare program. A total of 95 parents (53 intervention and 42 control) participated in the study. Parents' mean age was 30.42 years old, and majority (91.6%) were female. About 8.4% were Hispanic and 36.8% were Black. Over half of the parents were single, and 66.3% of the families had an annual family income <\$20,000. Nearly half of the parents were unemployed, and 57.9% had an education level of high school or less. On average, each family had three children living in the household. As shown in Table 3, parents' demographics are very comparable between the intervention and control groups. No adverse events were observed during the study.

Intervention Attendance

On average, children participated in 21 sessions of the daycare-based program and completed 21 letters to parents, with a range from 0 to 31. About 77.4% of the children (*n*=41) attended 16 or more sessions and completed 16 or more letters. Parents, on average, attended one parent meeting and participated in six weeks of the social media-based program. Seventeen (32.1%) parents attended all three parent meetings, and 34.0% participated in more than eight weeks of the social media-based program. The average daycare-based child program attendance rate was 66.1%, parent meeting participation rate was 43.5%, and social media-based program participate rate was 38.6%.

Intervention Effects

As presented in Table 4, the intervention did not result in significant effects on improving the primary outcome of parents' MVPA (*d*=-.36; *95%CI*=-.77, .05). The effects on improving their light physical activity were small and non-significant (*d*=.23; *95%CI*=-.18, .63).

However, the intervention had significant medium to large effects on increasing parents' nutrition knowledge (*d*=.86; *95%CI*=.44, 1.29) and physical activity knowledge (*d*=.51; *95%CI*=.10, .92), and decreasing their systolic BP (*d*=-1.11; *95%CI*=-1.54, -.67) and diastolic BP (*d*=-.58; *95%CI*=-.99, -.17). The significant effects on improving parents' physical activity self-efficacy (*d*=.47; *95%CI*=.06, .88), and decreasing their perceived parental weight (*d*=-.46;

95%CI=-.87, -.05) and permissive parenting style (*d*=-.49; *95%CI*=-.90, -.08) were small to medium.

The non-significant effects on increasing nutrition self-efficacy (*d*=.37; *95%CI*=-.04, .78), parental support on healthy eating (*d*=.21; *95%CI*=-.19, .62), and physical activity (*d*=.25; *95%CI*=-.16, .66) were small to medium. Additionally, small to medium non-significant effects were also observed on decreasing parental monitoring on child's eating (*d*=-.39; *95%CI*=-.80, .02) and authoritarian parenting style (*d*=-.30; *95%CI*=-.70, .11). Although participants in both groups experienced increases in both BMI and % body fat, the increases in the intervention group were slightly smaller than those in the control group (BMI: *d*=-.34; *95%CI*=-.74, .07; % body fat: *d*=-.32; *95%CI*=-.72, .09).

Intervention Effects after Adjusting for Cluster Random Effects

Table 5 demonstrates the results from mixed-effect models after adjusting for the cluster random effects of daycare centers and classrooms. In comparison to the control group, intervention parents engaged in more MVPA (*B*=.49, *p*=.874) and light physical activity (*B*=4.06, *p*=.308) post-intervention; however, these results were not statistically significant. The ICC for the random effects of daycare centers and classrooms was 0.06.

Compared to the control group, parents in the intervention group had significantly higher nutrition knowledge (*B*=.87, *p*=.009), physical activity knowledge (*B*=.95, *p*=.049), nutrition self-efficacy (*B*=.74, *p*=.025), and physical activity self-efficacy (*B*=.86, *p*=.013) post-intervention. In addition, fiber intake among intervention parents was significantly higher than control parents (*B*=2.99, *p*=.049). At post-intervention, parents in the intervention group had significantly lower % body fat (*B*=-2.56, *p*=.005) and systolic BP (*B*=-10.98, *p*=.005) than those in the control group. Although not statistically significant, the intervention showed positive effects on improving parents' F/V intake, parental support on healthy eating and physical activity, home physical activity environment, and authoritative parenting style. The ICCs ranged from 0 to 0.43 for these secondary outcomes.

Discussion

The goal of this study was to examine the preliminary efficacy of the FirstStep2Health vs usual care control among parents in mitigating familial obesogenic risk factors (MVPA, dietary quality, parental knowledge, self-efficacy, support, parenting style, feeding practice, and environment) and their anthropometric changes (BMI, % body fat, and BP). Overall speaking, although the FirstStep2Health intervention failed to result in significant improvements in the primary outcome of parents' MVPA in this study, it significantly mitigated many familial obesogenic risk factors particularly with regards to parental knowledge and self-efficacy in promoting physical activity and healthy eating behaviors. These significant improvements in parental knowledge (nutrition and physical activity) and self-efficacy (nutrition) are congruent with previous studies (3). Although not statistically significant, the positive increases in parental support and home environment (*d*=.19-.25) among intervention parents are meaningful because building a supportive home environment that is more conducive for healthy eating and physical activity is an essential first step to prevent childhood obesity (38).

For the accelerometer measured MVPA and light physical activity, both intervention and control parents experienced deceases in the study. The most plausible explanation for the unsuccessful results may be that the global pandemic has caused low attendance of the intervention and significant decreases in physical activity and increases in sedentary activity (39). Although many strategies (e.g., virtual intervention delivery format, make-up sessions) were applied to handle the challenges due to the COVID-19 pandemic, the overall intervention participation rates were still lower than what we had achieved in the feasibility study (39-66% vs. 77-87%) conducted before the pandemic (25). However, in the previous feasibility study, we also provided a small incentive ($5 per week) to compensate parents' time and efforts in participating in the weekly social media-based program. Given the hardships of poverty and the lack of spouse or partner support (62% were not married or partnered) among these vulnerable families, financial compensations may be necessary to overcome their unique challenges (e.g., being a single parent, a tight family budget) for intervention participation (26), especially when facing worsening financial challenges within the context of a global pandemic.

Although parents in both groups experienced some increases in their BMI and % body fat during the study, intervention parents had a smaller increase than control parents (d=-.34, -.32). In addition, intervention parents' % body fat was significantly lower than control parents at post-intervention after controlling for the baseline values and random cluster effects. This result is noteworthy because % body fat is a stronger indicator of cardiovascular risks than BMI (40). More importantly, intervention parents had decreases in both systolic and diastolic BP, indicating a reduced risk for cardiovascular disease (41). These results are somewhat surprising given that the intervention was intended to actively engage parents to reduce obesogenic risks among children rather than parents. One potential explanation is that children play a significant role in influencing their parents' food purchasing and consumption behaviors at home (42), and our innovative approach of enhancing the influences from children to parents via child letters was effective. However, due to the large proportion (39%) of parents not providing these outcome data, the results may be biased as parents who did not benefit from the intervention might have been more likely to skip data collection. Although further investigations with a larger sample size are needed, the study's results show some favorable effects of a childhood healthy lifestyle intervention on parents' cardiovascular risk factors including % body fat and BP.

Parental beliefs, attitudes, and practices regarding child feeding within the context of their children's obesity proneness improved among the intervention group. Most importantly, intervention parents' feeding practices were less likely to be influenced by their own perceived weight status (d=-.46), as compared to control parents. Although not statistically significant, the intervention group's parental control practices and attitudes regarding child feeding (restriction, pressure to eat, or monitoring) decreased (d=-.05 to -.39) over time. These positive results are encouraging as evidence indicates that parents' use of controlling restrictive feeding practices could result in negative effects on children's diet quality, and the detrimental effects were even stronger when fathers implemented the restrictive feeding practices than mothers (43). Thus, the father-mother differences in feeding practices should be carefully considered when engaging parents into improving diet quality among children.

The positive changes in intervention parents' feeding practices are also reflected in their improvements in parenting style including increases in authoritative parenting and decreases in both authoritarian and permissive parenting. The significant decreases in utilizing permissive parenting style (d=-.49) among intervention parents are critical because permissive parenting was reported to contribute to children's unhealthy lifestyles (44). Given that authoritative parenting is associated with healthy lifestyle behaviors and lower BMI in children (45, 46), promoting authoritative parenting can be an effective approach to prevent childhood obesity, particularly for achieving long-term sustaining outcomes. Unfortunately, very few obesity prevention interventions have assessed the changes in parenting styles (3, 9), limiting the comparison between this study's results on parenting style and findings from previous literature. Regardless, the FirstStep2Health intervention's effects on enhancing positive parenting can help children to have not only a healthier lifestyle, but also better mental health which can subsequently lead to fewer behavioral problems (47).

In terms of parents' diet quality changes, intervention parents demonstrated positive but not significant changes in increasing F/V and fiber intakes (d=.25 and .26, respectively). The positive effects on increasing parents' F/V intake were smaller than the effects (d=0.40) observed in the previous feasibility study (25), which may be due to the adverse effects of pandemic and low intervention engagement. The decreases in skin carotenoids (d=-.25) may have occurred because the control parents had a much lower level of skin carotenoids at baseline (236.83 vs. 256.33), as compared to intervention parents. Another reason is the potential existing of unmeasured confounders, as skin carotenoids were reported to be associated with smoking and sun exposure (48).

Limitations

This study has some limitations. First, this study had a relatively small sample size (n=95 Head Start parents) with 91.6% being female. Thus, generalizing to the general public or male caregiving adults would be inadvisable. Moreover, families were recruited based on their acceptance of the study recruitment flyer and voluntary agreement, which may limit the generalizability of results to non-participating parents. Second, this study was conducted under a global COVID pandemic context, the quarantine mandate and fear of virus transmission may contribute to the relatively low enrollment and participation rates in intervention sessions and in-person data collection for MVPA, height, weight, and % body fat among parents. Moreover, the potential additional stress that parents had encountered during the pandemic may have lowered the intervention effects. Thus, caution is needed when interpretating the results, especially their generalizability to a different social context. Third, we could not possibly control for every potential sociodemographic and lifestyle factor and the self-reported nature and short form of some measurements leave the possibility of residual confounding. In addition, the study sample size was small due to the challenging recruitment under a global pandemic context, a small ICC of 0.01 was used in power analysis, the significant level was not adjusted for multiple comparisons when examining all secondary outcomes, and potential confounders were not controlled for during the analyses, which may threaten the statistical conclusion validity. Finally, the study did not include a long-term follow-up evaluation, so future research should focus on assessing the long-term sustaining effects of the intervention.

Conclusions

The positive impacts of the dyadic FirstStep2Health intervention on parents are promising. In addition to the improvements in parental knowledge and self-efficacy, the intervention's contributions to improving parenting style and feeding practices as well as their anthropometric and cardiovascular outcomes (slowed the decreases in BMI and % body fat, decreased systolic and diastolic BP) are vital given the detrimental impacts of obesity-related comorbidities (e.g., hypertension, type 2 diabetes, cardiovascular diseases, and cancers) in the U.S. The dyadic intervention's positive effects on improving both children and parents' outcomes (23) further imply the bidirectional and intergenerational relationships within a family system. Therefore, dyadic interventions targeting both children at school and parents at home may have created a virtuous cycle, enhancing parents' supportive influences on children's behaviors and children's positive impact on parenting practices (49). Future endeavors should proactively engage parents in childhood obesity prevention efforts and evaluate the effects among both children and parents.

Table 1. The dyadic FirstStep2Health intervention for parent-child dyads

Component	Purpose	Description
Daycare-based child program	Increase knowledge and skill on healthy eating and physical activity	Children received weekly, age-appropriate, participatory learning sessions delivered by trained interveners on mindful eating (learning/tasting fruits/vegetables using five senses) and physical activity (practicing fun animal movements and activity games including yoga stretching movements and relaxing breathing activities). The program included two sessions per week, and each session lasted about 20 minutes.
Child letters	Connect school learning with home practice	Each week, children created two letters using stickers regarding a food or activity presented in the daycare-based program that they liked or wanted to try at home. Letters were sent privately to each parent via Facebook messenger or text messaging every Wed. and Fri. Parents were encouraged to discuss letters with their children and offer foods and activities desired by children. Parents were also asked to answer two Facebook multiple-choice questions related to the letters each week by Sun. midnight (a. What foods listed in your child's letter did you provide? b. What activities listed in your child's letter did your family try?).
Social media-based parent program	Foster a healthier home environment	Provided parents a weekly electronically retrievable flyer containing health information, family fun activities, and behavioral change strategies to help create a healthier home environment and encouraged interactive positive communication to promote peer support. Parents were asked to post a message or a picture on healthy eating and physical activity, positively respond to other parents' postings, and complete a 2-question quiz each week to reinforce information and strategies learned in the weekly flyer.
Parent group meetings	Promote behavioral change strategies	Three virtual meetings via zoom at week 1, 8 and 16, each meeting lasted about an hour. **Meeting 1**: program orientation, heathy cooking. **Meeting 2**: MyPlate plates, food labels, smart shopping. **Meeting 3**: program overview, community healthy eating and PA resources (e.g., farmer's markets, community gardens, nearby parks or other free or affordable PA facilities).
Motivational text messages	Increase parental motivation	Every week, three motivational text messages were sent at noon on Monday, Wednesday, and Friday to focus on parenting/family and lifestyle changes. For example, "*If there is anything that we wish to change in our children, we should first examine it and see whether it is not something that could better be changed in ourselves*."

Table 2. Study outcomes and measures

Outcome	Measure	Subscales	# Items	Example Question	Reliability/Validity in Literature	Cronbach's a in this study
Screen time	NHANES-Physical Activity and Physical Fitness Survey (50)	N/A	1	Over the past 30 days, on average how many HOURS per day did your child sit and watch TV or videos, or play video or computer games?	Reliability: *r*=0.63-0.84 (51)	N/A
F/V and fiber intake	Fruit-Vegetable-Fiber Screener (52)	F/V intake, fiber intake	10	How often do you eat green salad?	*r*=0.71 with full Block survey (52)	0.78
Knowledge	Knowledge On Preschoolers' Dietary Intake & Physical Activity (53)	Nutrition knowledge, physical activity knowledge	25	Food serving sizes are the same for children and adults.	N/A	N/A
Self-efficacy	Parental Self-Efficacy Scale (53)	Nutrition self-efficacy, physical activity self-efficacy	20	On a scale from 1-10, how confident are you that you can plan regular safe, but fun physical activity for your child?	a=0.72-0.75 (53)	0.95
Parental support	Parental Support Scale For Eating Habits And Physical Activity (54)	Nutrition parental support, physical activity parental support	12	During the LAST WEEK, how did you offer healthy foods to your child?	a=0.83-0.87 (55)	0.84
Parenting style	Parenting Style and Dimensions Questionnaire (56)	Authoritative, authoritarian, permissive parenting style	32	I allow my child to give input to family rules.	a=0.64-0.91 (57)	0.82
Parent feeding practices	Child Feeding Questionnaire (58)	Perceived responsibility for child feeding, perceived parent weight status, perceived child weight status, concerns about child weight, restrictions of child's access to food, pressure to ask child to eat more, monitoring of child's eating	28	If my child says "I'm not hungry," I try to get her to eat anyway.	a=0.71-0.93 *r*=-0.26-0.53 with child BMI (59)	0.75
Home environment	Family Nutrition and Physical Activity screening tool (60)	Home eating environment, home physical activity environment	20	How often does your child eat while watching TV (Includes meals or snacks)?	Correlated with child BMI (61)	0.82

Table 3. Demographic characteristics of parents

Variable	Total (*N*=95)		Intervention (*n*=53)		Control (*n*=42)		t-test/Chi-square test	
	N (mean)	*% (SD)*	*N (mean)*	*% (SD)*	*N (mean)*	*% (SD)*	t/χ^2	p-value
Age (years, 21-48)	30.42	5.73	30.74	6.11	30.02	5.27	.60	.551
Sex (Female)							.81	1.0
Female	87	91.6	48	90.6	39	92.9		
Male	7	7.4	4	7.5	3	7.1		
Other	1	1.1	1	1.9	0	0		
Ethnicity (Hispanic)	8	8.4	3	5.7	5	11.9	1.19	.459
Race							8.59	.077
White	44	46.3	18	34	26	61.9		
Black	35	36.8	23	43.4	12	28.6		
Mixed race	9	9.5	6	11.3	3	7.1		
Other	7	7.4	6	11.3	1	2.4		
Marital status							1.78	.424
Married/partnered	36	37.9	23	43.4	13	31		
Separated/widowed	5	5.3	3	5.7	2	4.8		
Single	54	56.8	27	50.9	27	64.3		
Annual family income							6.13	.077
< $20,000	63	66.3	32	60.4	31	73.8		
$20,000-$29,999	15	15.8	8	15.1	7	16.7		
$30,000-$49,999	16	16.8	13	24.5	3	7.1		
≥ $50,000	1	1.1	0	0	1	2.4		
Employment status							.20	.929
Full-time	23	24.2	13	24.5	10	23.8		
Part-time	25	26.3	13	24.5	12	28.6		
No	47	49.5	27	50	20	47.6		
Education level							4.54	.313
< high school	15	15.8	9	17	6	14.3		
High school	40	42.1	22	41.5	18	42.9		
Some college	29	30.5	13	24.5	16	38.1		
Technical/community college	10	10.5	8	15.1	2	4.8		
Bachelor's degree	1	1.1	1	1.9	0	0		
Number of children							6.21	.527
1 child	18	19.2	10	18.9	8	19.5		
2 children	30	31.9	17	32.1	13	31.7		
3 children	22	23.4	13	24.5	9	22		
4 children	13	13.8	8	15.1	5	12.2		
≥ 5 children	11	11.7	5	9.4	6	14.6		
Missing	1	1.1	0	0	1	2.4		

Table 4. Descriptions of parents' outcomes over time

Outcome	Intervention				Control				Effect Sizes and 95% CI		
	Baseline		Post-Intervention		Baseline		Post-Intervention				
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Cohen's d*	*LL*	*UL*
Psychosocial Outcomes											
Nutrition knowledge (n=95)	6.72	1.34	7.45	1.27	7.24	1.46	6.68	1.87	**.86**	.44	1.29
Physical activity knowledge (n=95)	12.02	1.50	12.53	1.64	12.19	1.73	11.58	2.42	**.51**	.10	.92
Nutrition self-efficacy (n=95)	8.36	1.51	8.95	1.35	8.16	1.55	8.18	1.68	.37	-.04	.78
Physical activity self-efficacy (n=95)	8.59	1.58	9.27	1.12	8.56	1.33	8.38	1.70	**.47**	.06	.88
Nutrition parental support (n=94)	4.12	.91	4.52	.80	4.17	.98	4.39	.71	.21	-.19	.62
Physical activity parental support (n=94)	4.71	1.26	5.15	1.05	4.55	.96	4.64	1.25	.25	-.16	.66
Parenting style (n=94)											
Authoritative	4.20	.48	4.35	.52	4.02	.72	4.0	.76	.27	-.14	.67
Authoritarian	1.64	.48	2.46	1.24	1.63	.45	2.78	.91	-.30	-.70	.11
Permissive	2.40	.80	2.16	.84	2.26	.69	2.41	.88	**-.49**	-.90	-.08
Parent feeding practices (n=95)											
Feeding responsibility	4.67	.52	4.65	.71	4.59	.66	4.58	.64	-.01	-.87	.39
Perceived parent weight	3.14	.36	3.11	.43	3.15	.41	3.31	.46	**-.46**	-.87	-.05
Perceived child weight	2.97	.29	2.95	.32	2.93	.25	2.88	.29	.11	-.30	.52
Concern about child weight	1.46	.82	1.46	1.05	1.20	.31	1.13	.26	.09	-.32	.50
Restriction	3.54	.74	3.33	.86	3.54	.74	3.37	.87	-.05	-.46	.35
Pressure to eat	3.13	1.0	2.86	.99	2.79	.84	2.68	.80	-.16	-.56	.25
Monitoring	4.21	.82	4.04	1.10	3.82	1.21	4.13	.83	-.39	-.80	.02
Home eating environment (n=94)	30.94	4.24	31.68	4.13	30.74	3.52	30.74	4.07	.19	-.22	.59
Home physical activity environment (n=94)	30.52	5.07	31.24	4.78	28.74	4.59	28.42	4.71	.21	-.19	.62
Behavioral Outcomes											
Physical Activity											
Light (min/hour, n=42)	17.89	3.77	15.72	9.19	19.03	8.27	14.43	9.17	.23	-.18	.63

MVPA (min/hour, primary outcome, n=42)	15.98	7.48	8.25	6.75	14.48	6.95	10.14	9.77	-.36	-.77	.05
Diet Quality											
F/V intake (servings/day, n=95)	3.39	1.93	4.52	2.46	2.95	2.03	3.44	1.58	.25	-.15	.66
Fiber intake (servings/day, n=95)	14.31	5.66	17.52	7.26	12.69	5.93	14.03	5.12	.26	-.14	.67
#Skin carotenoids (n=20)	256.33	55.88	252.63	41.61	236.83	50.14	250	44.21	-.25	-.65	.16
Screen time (hours/day, n=95)	6.40	5.29	4.93	4.71	7.38	6.18	5.93	5.67	-.003	-.41	.40
Physical Outcomes											
BMI (n=58)	29.55	8.32	31.3	8.37	32.43	9.51	33.58	8.91	-.34	-.74	.07
% body fat (n=55)	36.07	9.01	37.42	6.58	39.28	10.85	41.8	8.3	-.32	-.73	.09
Systolic BP (n=57)	122.53	18.69	120.98	21.12	117.05	9.02	129	17.25	**-1.11**	-1.54	-.67
Diastolic BP (n=57)	75.14	13.39	77	14.88	75.98	6.49	82.44	9.41	**-.58**	-.99	-.17
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*bOR*	*LL*	*UL*
Proportion of OW/B (n=58)	23	69.7	23	79.3	13	61.9	16	80	.96	.23	3.95

Note. [a]Cohen's d was calculated using mean difference and the standard deviation of the mean difference in each group (62), and positive values indicate the intervention group had a mean increase from baseline to post-intervention when comparing to the control group. [b]OR was calculated using the post-intervention OW/O rate in each group. #Skin carotenoids were measured only in the study Year 2 among 20 parents using Veggie Meter; SD=standard deviation; BMI=body mass index; F/V=fruits/vegetables; MVPA=moderate to vigorous physical activity; OW/O=overweight/obesity; OR=odds ratio; CI=confidence interval; LL=lower limit; UL=upper limit.

Table 5. Intervention effects on parents' outcomes after adjusting for random cluster effects of daycare centers and classrooms

Outcome	*B*	*95% CI for B*	*p-value*
Psychosocial Outcomes			
Nutrition knowledge	.87	.23, 1.52	**.009***
Physical activity knowledge	.95	.002, 1.89	**.049***
Nutrition self-efficacy	.74	.09, 1.39	**.025***
Physical activity self-efficacy	.86	.19, 1.53	**.013***
Nutrition parental support	.27	-.05, .58	.099
Physical activity parental support	.53	-.01, 1.07	.055
Parenting style			
Authoritative	.27	-.01, .55	.060
Authoritarian	-.28	-.81, .25	.292
Permissive	-.27	-.62, .09	.139
Parent feeding practices			
Feeding responsibility	.06	-.27, .40	.702
Perceived parent weight	-.17	-.35, .02	.081
Perceived child weight	.04	-.08, .17	.502
Concern about child weight	.22	-.14, .58	.233
Restriction	-.03	-.38, .33	.879
Pressure to eat	.13	-.28, .55	.526
Monitoring	-.18	-.67, .30	.448
Home eating environment	.67	-1.04, 2.38	.439
Home physical activity environment	1.91	-.19, 4	.073
Proximal Behavioral Changes			
Physical Activity			
Light (min/hour)	4.06	-3.98, 12.10	.308
MVPA (min/hour, primary outcome)	.49	-5.82, 6.81	.874
Diet Quality			
F/V intake	1.0	-.01, 2.01	.051
Fiber	2.99	.02, 5.97	**.049***
#Skin carotenoids	32.16	-40.41, 104.72	.330
Screen time (hours/day)	-.84	-3.38, 1.70	.512
Distal Anthropometric Outcomes			
BMI	-.77	-1.94, .40	.191
% body fat	-2.56	-4.29, -.84	**.005***
Systolic BP	-10.98	-18.31, -3.64	**.005***
Diastolic BP	-2.78	-8.86, 3.31	.360
	OR	*95% CI for OR*	*p-value*
Proportion of OW/B	1.77	.04, 87.5	.769

Note. **p* ≤ .05; #Skin carotenoids were measured in the study Year 2 among 20 parents using Veggie Meter; B=unstandardized regression coefficient; CI=confidence interval; BMI=body mass index; F/V=fruits/vegetables; MVPA=moderate to vigorous physical activity; OW/O=overweight/obesity; OR=odds ratio.

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Effects of the Dyadic FirstStep2Health Intervention on Parents' Behavior and Anthropometric Outcomes: A Secondary Analysis of A Cluster Randomized Trial

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Abstract

Objectives. This study aimed to examine the preliminary efficacy of the *FirstStep2Health* vs usual care control on improving parents' lifestyle behaviors (moderate to vigorous physical activity, screen time, fruit/vegetable and fiber intake, skin carotenoids), nutrition and physical activity knowledge, self-efficacy, support, parenting style, feeding practices, home environment, anthropometric outcomes (body mass index, percent body fat), and blood pressure from baseline to post-intervention after adjusting for random cluster effects.

Design. A cluster randomized controlled trial with 10 Head Start daycare centers (ClinicalTrials.gov ID: NCT04164277; 5 intervention, 5 control) was conducted using computer-generated randomization after baseline data collection.

Setting. U.S. Head Start daycare centers.

Participants. 95 parent-child dyads (53 intervention, 42 control).

Interventions. The 16-week, dyadic, *FirstStep2Health* intervention included: 1) a daycare-based child program on healthy mindful eating and physical activity, 2) child letters to parents to connect school learning with home practice, 3) social media-based parent program to assist parents to promote healthy eating and physical activity at home, 4) virtual group parent meetings via Zoom on topics related to healthy eating and physical activity, and 5) weekly motivational messages to increase parental motivation to build a healthy home environment.

Results. Mixed-effect models were used to examine intervention effects, adjusting for baseline outcome and cluster effects at the daycare and classroom levels. Intervention parents engaged in more MVPA (B=.49, p=.874) post-intervention than controls, though not significantly. However, intervention parents showed significantly higher nutrition knowledge (B=0.87, p=.009), physical activity knowledge (B=0.95, p=.049), nutrition self-efficacy (B=0.74, p=.025), and physical activity self-efficacy (*B*=0.86, *p*=.013) compared to controls at post-intervention. Fiber intake was also significantly higher (*B*=2.99, *p*=.049), and intervention parents had lower % body fat (*B*=-2.56, *p*=.005) and systolic BP (*B*=-10.98, *p*=.005) post-intervention. No significant effects were found for F/V intake, parental support for healthy behaviors, home physical activity environment, or authoritative parenting style.

Conclusions. Future endeavors to proactively engage parents in a dyadic childhood obesity prevention approach such as the *FirstStep2Health* intervention are warranted to improve outcomes among both children and parents.

Keywords: FirstStep2Health intervention; obesity prevention; obesogenic risk factors; parent-child dyads

Strengths and limitations of this study

- The study is a cluster randomized controlled trial to account for cluster effects of daycare centers and classrooms.
- The study applied objective measurements including height, weight, percent body fat, blood pressure, and skin carotenoids.
- The study sample is ethnically and racially diverse with low-socioeconomic status.
- The study occurred under a global pandemic context, limiting the generalizability.
- The study had a relatively small sample size (n=95 Head Start parents) with 91.6% being female.

Introduction

Parents significantly influence children's health behaviors [1, 2]. Childhood obesity experts emphasize implementing obesity prevention strategies with parents during preschool years rather than later in childhood, because parental attitudes, beliefs, and behaviors play a critical role in shaping young children's lifestyles and weight status [3]. Children with parents who are overweight or obese have a higher risk of developing similar conditions both during childhood and into adulthood [4]. Especially before age 12, children's trajectories for developing overweight or obesity are largely influenced by their parents' weight status [5]. For example, a recent meta-analysis with 23 studies [4] found a pooled odds ratio (OR) of 1.97 (95%CI=1.85-2.10) for overweight or obesity between parents and children.

With a high prevalence of overweight (30.7%) or obesity (42.4%) among United States (U.S.) adults [5], children nowadays are at an elevated risk of developing these conditions unless timely and effective parent-involved interventions are implemented. Dyadic interventions targeting both parents and children, rather than focusing on one group alone [6], are shown to have greater sustaining effects on reducing children' body mass index (BMI) [7]. However, effective obesity interventions targeting young children and parents living in poverty remain limited [8]. Furthermore, active parent engagement in childhood obesity prevention interventions has been linked to improvements in children's physical activity and diet quality [9]. Yet, the specific benefits parents experience in dyadic interventions remain relatively obscure [10].

Since the family, particularly parents, heavily influences children's diet and physical activity choices [1], obesity is seen as a family issue. Familial factors – such as genetics and shared environments – contribute to childhood obesity, but focusing on the modifiable shared obesogenic environment can better address intergenerational obesity transmission [11, 12]. This environment is usually highly conducive to unhealthy lifestyles, such as high screen time, low physical activity, and inadequate intake of fruits/vegetables [F/V] and fiber, among both parents and children [13]. Thus, to eliminate childhood obesity within a family context, effective dyadic obesity prevention interventions should aim to cultivate a healthy home environment that fosters nutritious eating and regular physical activity.

Most dyadic interventions focus on improving parents' knowledge of physical activity, nutrition, and feeding practices, but rarely address parents' lifestyle behaviors or anthropometric outcomes [3]. As strong correlations exist between parents' and children's lifestyles and anthropometrics [4, 14], thoroughly understanding the impact of dyadic interventions on parents' lifestyle behaviors and anthropometrics (e.g., BMI, % body fat) is crucial in mitigating obesity-related comorbidities from a family perspective. Recognizing how these interventions benefit both parents and children is valuable, as it highlights the reciprocal influences within the family system [2]. Moreover, this understanding can lead to the development of more effective interventions for improving family health, fostering supportive home environments, and promoting positive behavior changes within the entire family system.

Given that percent body fat is a stronger predictor of cardiovascular risk compared to BMI [15], and that systolic and diastolic blood pressure (BP) are key indicators of cardiovascular health [16], evaluating these metrics in parents is fundamental for generating evidence to improve family cardiovascular health. Therefore, the purpose of this study was to evaluate the preliminary efficacy of *FirstStep2Health*, a school- and home-based healthy lifestyle intervention, on improving parents' moderate to vigorous physical activity (MVPA), diet quality (i.e., F/V and fiber intake, skin carotenoids), screen time, proportion of overweight/obesity, BMI, % body fat, BP, nutrition and physical activity knowledge, self-efficacy, parental support, parenting style, feeding practices, and home environment after adjusting for random cluster effects.

Methods

Conceptual Framework

The intervention development was grounded in both the Actor-Partner Interdependence Model and the Social Cognitive Theory [17, 18]. The Actor-Partner Interdependence Model endorses the reciprocal influences between a parent and a child within the family context [19, 20]. Based on the Social Cognitive Theory, individuals' behaviors can be modified by their knowledge, self-efficacy, social support, and environment. Parents require sufficient knowledge and self-efficacy to effectively promote and support their children in adopting healthy lifestyles [21]. Additionally, they need to employ effective parenting practices to integrate healthy foods and regular physical activity into their daily family routines [22]. Building on these theories and evidence, our *FirstStep2Health* dyadic intervention targeted parents to enhance their knowledge, self-efficacy, and support to improve their parenting style and feeding practices, fostering a nurturing and healthy home enviornment. To enhance the influences from children to parents, we implemennted an innovative approch that connected school learning with home practices to further promote healthy eating and physical activity behaviors at home.

Overview of the *FirstStep2Health* Study

This cluster randomized controlled trial was conducted with 10 Head Start daycare centers from the Midwestern U.S. in fall 2021 to spring 2023. A cluster randomized controlled trial was used to minimize contamination because children are clustered within daycare classrooms and centers. The intervention period was November to March in each year. The intervention effects on improving children's outcomes (Primary Aim of the trial) were published in a prior manuscript (23) and this current manuscript focused on examining the effects on parents' outcomes (Secondary Aim). The study statistician randomly assigned the 10 centers into intervention (5 centers) or control (5 centers) groups using computer-generated random numbers after participant enrollment and baseline data collection. The study was approved by the local university Biomedical and Health Institutional Review Board (STUDY00001629) and registered in ClinicalTrials.gov (NCT04164277).

We mainly used recruitment flyers to recruit participants. Classroom teachers helped to distribute the study recruitment flyers to families. Interested families were instructed to use the survey link or QR code on the flyer to complete the screening and enrollment survey and contact the study team with any questions. A face-to-face recruitment method was also used. The trained recruitment team went to each daycare center to recruit families during daycare drop-off and pick-up times. A $5 e-gift card was provided to each family who completed the screening and enrollment survey regardless of their participation status.

Head Start daycare centers serving children aged 3-5 years old were eligible to participate in the study. Inclusion criteria for parents included: 1) was the primary adult caregiver (parent or legal guardian ≥18 years old) for the Head Start children, 2) had at least weekly Internet access to use Facebook or the study private website to participate in designed intervention activities, and 3) could understand and speak English. Parents provided written consent for themselves as well as their children to participate in the study. In addition, children aged five years or older needed to provide verbal assent in order to be enrolled with their adult caregivers. All eligible and consented children and parents from participating daycare centers were enrolled in the study.

Assuming an overall cluster effect intraclass correlation coefficient (ICC)=0.01 based on prior literature [24], no variations between clusters (i.e., differences among clusters are minimal, as all clusters are urban Head Start daycare centers operated by the same organization), and significance level=.05, a sample size of 6 daycare centers, 24 classrooms, and 130 participants would provide a power of .80 to identify an effect size of 0.50 in the trial's primary outcome of children's MVPA [23]. The selected effect size of 0.50 was based on the results observed in our previous quasi-experimental feasibility study [25].

Patient and Public Involvement

Patients or the public were not involved in the design, conduct, reporting, or dissemination plans of our research.

Intervention

The 16-week, dyadic, *FirstStep2Health* intervention was tailored to economically marginalized families with young children [23]. We actively engaged Head Start teachers and parents to develop culturally appropriate content for the intervention through focus groups and interviews [25, 26]. The intervention included: 1) a 16-week (total 32 sessions) daycare-based child program on healthy mindful eating and physical activity, tailored to young children's developmental stage; 2) 32 child letters to parents to connect school learning with home practice; 3) a 16-week social media-based parent program to assist parents to promote healthy eating and physical activity at home; 4) 3 virtual group parent meetings at week 1, 8, and 16 via Zoom on topics related to healthy eating and physical activity, we had to change the meeting delivery format from in-person to virtual Zoon sessions due to the COVID-19 pandemic; and 5) weekly motivational messages (3 times/week for 16 weeks) to increase parental motivation to build and sustain a healthy home environment. The daycare-based child program was delivered in-person by trained interventionists to all children enrolled in the intervention daycare centers instead of pulling only the study children out. This approach was highly recommended by Head Start administrators and can help reduce potential feelings of insecurity and anxiety among children. Make-up sessions were offered to ensure the full dose of 32 sessions was achieved when intervention classes were closed due to the spread of COVID-19 cases. To promote mindful eating and regular physical activity at home, each intervention family received a healthy cookbook containing budget-friendly family recipes, adult and child MyPlate plates to guide appropriate portion size, and a community resource booklet to help sustain healthy behavioral changes. Table 1 provides details of the intervention.

The usual care control group did not receive any intervention during the study period. After post-intervention data collection, a 2-week mini program was offered. The 2-week mini program included: 1) children received a 2-week daycare-based child program in daycares, 2) children completed two letters to parents to share what they had learned from the 2-week child program, and 3) parents received a program handbook containing all intervention instructions and flyers as well as supplies including a healthy cookbook, 2 MyPlate plates, and a community resource booklet.

Intervention implementation fidelity monitoring. To monitor the implementation fidelity of the child program, trained independent process evaluators observed six randomly selected sessions (two sessions at week 1-4, two sessions at week 7-10, and two sessions at week 13-16) at each intervention classroom. Feedback and suggestions were provided to the interventionists for further improvement. A remediation plan with additional training would be implemented if the total score was less than 4 out of a 6-point range. The project manager conducted three parent meetings following developed scripts to ensure consistent delivery. The study process evaluators observed each parent meeting to evaluate the delivery fidelity in comparison with the developed scripts.

Data Collection

We collected individual outcome data at baseline before intervention start and immediately post-intervention. At each time point, parents received a survey link via text message or email to complete an online survey via Qualtrics. Then, a face-to-face appointment was scheduled to complete the measurements of skin carotenoids, height, weight, % body fat, and BP; and distribute ActiGraph GT3X-plus accelerometers to assess physical activity. The face-to-face data collection appointment mainly occurred at a private daycare classroom within participating Head Start centers. However, we also offered home visiting data collection options for participants who were uncomfortable leaving home due to pandemic concerns. Some in-person data collection events were held at a local university conference room when a participating Head Start center was closed due to the spread of COVID-19 cases. Trained and blinded from randomization status, data collectors collected data from participants.

Measures

Parents completed reliable and valid instruments in an online survey measuring their demographics, F/V and fiber intake, screen time in hours per day, nutrition and physical activity knowledge, self-efficacy, support, parenting style, feeding practices, and home eating and physical activity environment (see Table 2).

MVPA was measured using the ActiGraph GT3X-plus accelerometer with the wrist-worn approach [27]. ActiLife software was used to initialize each ActiGraph and set it to begin data collection at 5AM on the first day. We instructed parents to wear the ActiGraph on their dominant wrist (attached to an adjustable woven nylon wristband) from the time getting out of bed in AM to going to sleep at night for seven consecutive days (not worn bathing/swimming). An auto text message reminder was sent to parents every morning at 7AM via our developed

HIPAA compliant platform Twilio (www.twilio.com). Parents' physical activity was reported as: sedentary 0-99, light 100-2019, moderate 2020-5998, and vigorous ≥5999 counts per minutes [28]. Data were determined valid when wear time by the parents was at least eight hours per day for at least two days [29, 30].

Skin carotenoids were measured by the pressure-mediated reflection spectroscopy with the Veggie Meter (®Longevity Link Corporation). Skin carotenoids are being used as a non-invasive biological marker for F/V intake due to their consistent positive correlation with plasma/serum carotenoids in the adult population [31]. Evidence has supported the sensitivity of using Veggie Meter to detect changes in skin carotenoids in experimental studies among ethnically/racially diverse populations [32].

Height and weight were measured by the Shortboards® Stadiometer to the nearest 0.1 cm and Seka model 874 scale to the nearest 0.01 kg, respectively. BMI was calculated using measured height and weight: weight (kg)/[height (m)]^2. We used the BC-533 InnerScan Body Composition Monitor to measure parents' % body fat. During the measurements, parents were asked to take off shoes, socks, or bulky clothes. For measuring % body fat, each parent stepped onto the scale surface and aligned feet with the four electrodes.

Parents' BP was measured by the Omron HEM-705-CP digital blood pressure monitor following the protocol established by the American Heart Association [33]. The day before data collection, parents were informed to not smoke, exercise, or injest caffeine during the 30 minutes before their BP was taken. During BP measurement, parents were instructed to keep their left arm on the measurement table (right arm was used if the left arm had a surgery or injury), sit upright, back straight, with feet flat on the floor.

To increase measurement reliability and validity, two measurements were taken for height, weight, % body fat, and BP. A third measurement would be taken, when the two measurements differed by ≥0.5 cm for height, ≥0.5 kg for weight, ≥1% for % body fat, and ≥5 mmHg for BP. To calculate the final measurment value, the two closest measurements were averaged.

Data Analysis

IBM SPSS Statistics 27 was used for all data analyses following the intention-to-treat principle to preserve the original randomization. That is, data were analyzed based on participants' originally assigned group regardless of whether they received the intervention or not. Statistically significant level was set at .05. Means, standard deviations, ranges, frequencies, and percentages were calculated to describe study variables. To compare group differences in individual demographics while adjusting for cluster effects of daycare centers and classrooms, mixed-effect models were applied and identified significant demographics were adjusted in the further analyses. Mixed-effect models with restricted maximum likelihood estimation method and Satterthwaite approximations for degrees of freedom [34] were applied to examine intervention effects. In the mixed-effect models, post-intervention outcome was the dependent variable, fixed effect independent variable was group (intervention vs. control), and covariate was baseline outcome and any identified significant demographics. Random cluster effects included both daycare centers and classrooms, as parents' children were nested in daycare centers and classrooms. The regression coefficient *B* was estimated to indicate the differences in dependent variables between the intervention and control groups, while accounting for covariates and random cluster effects. Further, when the dependent variable was the proportion of overweight/obesity, generalized linear mixed-effect model with logic link was performed to examine the group differences at post-intervention after controlling for baseline weight status and cluster random effects. The advantage of using mixed-effect models is that correct inference can be estimated even when missing data exist [35]. Effect sizes of Cohen's *d* and OR were calculated to describe the intervention effects: small (d=0.2, OR=1.68), medium (d=0.5, OR=3.47), and large (d=0.8, OR=6.71) [36, 37].

Results

Participants

The study's flow diagram was published in a prior manuscript reporting the intervention effects on improving children's outcomes [23]. No daycare center or classroom was lost to follow-up. The loss to follow-up rate among children was 10.5%, primarily due to children leaving Head Start daycare program. A total of 95 parents (53 intervention and 42 control) participated in the study. Parents' mean age was 30.42 years old, and majority (91.6%) were female. About 8.4% were Hispanic and 36.8% were Black. Over half of the parents were single, and 66.3% of the families had an annual family income <$20,000. Nearly half of the parents were unemployed, and 57.9% had an education level of high school or less. On average, each family had three children living in the household. As shown in Table 3, parents' demographics are very comparable between the intervention and control groups. No adverse events were observed during the study.

Intervention Attendance

On average, children participated in 21 sessions of the daycare-based program and completed 21 letters to parents, with a range from 0 to 31. About 77.4% of the children (n=41) attended 16 or more sessions and completed 16 or more letters. Parents, on average, attended one parent meeting and participated in six weeks of the social media-based program. Seventeen

(32.1%) parents attended all three parent meetings, and 34.0% participated in more than eight weeks of the social media-based program. The average daycare-based child program attendance rate was 66.1%, parent meeting participation rate was 43.5%, and social media-based program participate rate was 38.6%.

Intervention Effects

As presented in Table 4, the intervention did not result in significant effects on improving parents' MVPA (*d*=-.36; *95%CI*=-.77, .05). The effects on improving their light physical activity were small and non-significant (*d*=.23; *95%CI*=-.18, .63).

However, the intervention had significant medium to large effects on increasing parents' nutrition knowledge (*d*=.86; *95%CI*=.44, 1.29) and physical activity knowledge (*d*=.51; *95%CI*=.10, .92), and decreasing their systolic BP (*d*=-1.11; *95%CI*=-1.54, -.67) and diastolic BP (*d*=-.58; *95%CI*=-.99, -.17). The significant effects on improving parents' physical activity self-efficacy (*d*=.47; *95%CI*=.06, .88), and decreasing their perceived parental weight (*d*=-.46; *95%CI*=-.87, -.05) and permissive parenting style (*d*=-.49; *95%CI*=-.90, -.08) were small to medium.

The non-significant effects on increasing nutrition self-efficacy (*d*=.37; *95%CI*=-.04, .78), parental support on healthy eating (*d*=.21; *95%CI*=-.19, .62), and physical activity (*d*=.25; *95%CI*=-.16, .66) were small to medium. Additionally, small to medium non-significant effects were also observed on decreasing parental monitoring on child's eating (*d*=-.39; *95%CI*=-.80, .02) and authoritarian parenting style (*d*=-.30; *95%CI*=-.70, .11). Although participants in both groups experienced increases in both BMI and % body fat, the increases in the intervention group were slightly smaller than those in the control group (BMI: *d*=-.34; *95%CI*=-.74, .07; % body fat: *d*=-.32; *95%CI*=-.72, .09).

Intervention Effects after Adjusting for Cluster Random Effects

Table 5 demonstrates the results from mixed-effect models after adjusting for the cluster random effects of daycare centers and classrooms. In comparison to the control group, intervention parents engaged in more MVPA (B=.49, p=.874) and light physical activity (B=4.06, p=.308) post-intervention; however, these results were not statistically significant. The ICC for the random effects of daycare centers and classrooms was 0.06.

Compared to the control group, parents in the intervention group had significantly higher nutrition knowledge (B=.87, p=.009), physical activity knowledge (B=.95, p=.049), nutrition self-efficacy (B=.74, p=.025), and physical activity self-efficacy (B=.86, p=.013) post-intervention. In addition, fiber intake among intervention parents was significantly higher than control parents (B=2.99, p=.049). At post-intervention, parents in the intervention group had significantly lower % body fat (B=-2.56, p=.005) and systolic BP (B=-10.98, p=.005) than those in the control group. Although not statistically significant, the intervention showed positive effects on improving parents' F/V intake, parental support on healthy eating and physical activity, home physical activity environment, and authoritative parenting style. The ICCs ranged from 0 to 0.43 for these outcomes.

Discussion

The goal of this study was to examine the preliminary efficacy of the *FirstStep2Health* vs usual care control among parents in mitigating familial obesogenic risk factors (MVPA, dietary quality, parental knowledge, self-efficacy, support, parenting style, feeding practice, and environment) and their anthropometric changes (BMI, % body fat, and BP). Overall speaking, although the *FirstStep2Health* intervention failed to result in significant improvements in parents' MVPA in this study, it significantly mitigated many familial obesogenic risk factors particularly with regards to parental knowledge and self-efficacy in promoting physical activity and healthy eating behaviors. These significant improvements in parental knowledge (nutrition and physical activity) and self-efficacy (nutrition) are congruent with previous studies (3). Although not statistically significant, the positive increases in parental support and home environment (d=.19-.25) among intervention parents are meaningful because building a supportive home environment that is more conducive for healthy eating and physical activity is an essential first step to prevent childhood obesity [38].

For the accelerometer measured MVPA and light physical activity, both intervention and control parents experienced deceases in the study. The most plausible explanation for the unsuccessful results may be that the global pandemic has caused low attendance of the intervention and significant decreases in physical activity and increases in sedentary activity [39]. Although many strategies (e.g., virtual intervention delivery format, make-up sessions) were applied to handle the challenges due to the COVID-19 pandemic, the overall intervention participation rates were still lower than what we had achieved in the feasibility study (39-66% vs. 77-87%) conducted before the pandemic [25]. However, in the previous feasibility study, we also provided a small incentive ($5 per week) to compensate parents' time and efforts in participating in the weekly social media-based program. Given the hardships of poverty and the lack of spouse or partner support (62% were not married or partnered) among these vulnerable families, financial compensations may be necessary to overcome their unique challenges (e.g., being a single parent, a tight family budget) for intervention participation [26], especially when facing worsening financial challenges within the context of a global pandemic.

Although parents in both groups experienced some increases in their BMI and % body fat during the study, intervention parents had a smaller increase than control parents (d=-.34, -.32).

In addition, intervention parents' % body fat was significantly lower than control parents at post-intervention after controlling for the baseline values and random cluster effects. This result is noteworthy because % body fat is a stronger indicator of cardiovascular risks than BMI [40]. More importantly, intervention parents had decreases in both systolic and diastolic BP, indicating a reduced risk for cardiovascular disease [41]. These results are somewhat surprising given that the intervention was intended to actively engage parents to reduce obesogenic risks among children rather than parents. One potential explanation is that children play a significant role in influencing their parents' food purchasing and consumption behaviors at home [42], and our innovative approach of enhancing the influences from children to parents via child letters was effective. However, due to the large proportion (39%) of parents not providing these outcome data, the results may be biased as parents who did not benefit from the intervention might have been more likely to skip data collection. Although further investigations with a larger sample size are needed, the study's results show some favorable effects of a childhood healthy lifestyle intervention on parents' cardiovascular risk factors including % body fat and BP.

Parental beliefs, attitudes, and practices regarding child feeding within the context of their children's obesity proneness improved among the intervention group. Most importantly, intervention parents' feeding practices were less likely to be influenced by their own perceived weight status (d=-.46), as compared to control parents. Although not statistically significant, the intervention group's parental control practices and attitudes regarding child feeding (restriction, pressure to eat, or monitoring) decreased (d=-.05 to -.39) over time. These positive results are encouraging as evidence indicates that parents' use of controlling restrictive feeding practices could result in negative effects on children's diet quality, and the detrimental effects were even stronger when fathers implemented the restrictive feeding practices than mothers [43]. Thus, the father-mother differences in feeding practices should be carefully considered when engaging parents into improving diet quality among children.

The positive changes in intervention parents' feeding practices are also reflected in their improvements in parenting style including increases in authoritative parenting and decreases in both authoritarian and permissive parenting. The significant decreases in utilizing permissive parenting style (*d*=-.49) among intervention parents are critical because permissive parenting was reported to contribute to children's unhealthy lifestyles [44]. Given that authoritative parenting is associated with healthy lifestyle behaviors and lower BMI in children [45, 46], promoting authoritative parenting can be an effective approach to prevent childhood obesity, particularly for achieving long-term sustaining outcomes. Unfortunately, very few obesity prevention interventions have assessed the changes in parenting styles [3, 9], limiting the comparison between this study's results on parenting style and findings from previous literature. Regardless, the *FirstStep2Health* intervention's effects on enhancing positive parenting can help children to have not only a healthier lifestyle, but also better mental health which can subsequently lead to fewer behavioral problems [47].

In terms of parents' diet quality changes, intervention parents demonstrated positive but not significant changes in increasing F/V and fiber intakes (*d*=.25 and .26, respectively). The positive effects on increasing parents' F/V intake were smaller than the effects (*d*=0.40) observed in the previous feasibility study [25], which may be due to the adverse effects of pandemic and low intervention engagement. The decreases in skin carotenoids (*d*=-.25) may have occurred because the control parents had a much lower level of skin carotenoids at baseline (236.83 vs. 256.33), as compared to intervention parents. Another reason is the potential existing of unmeasured confounders, as skin carotenoids were reported to be associated with smoking and sun exposure [48].

Limitations

This study has some limitations. First, this study had a relatively small sample size (n=95 Head Start parents) with 91.6% being female. Thus, generalizing to the general public or male caregiving adults would be inadvisable. Moreover, families were recruited based on their acceptance of the study recruitment flyer and voluntary agreement, which may limit the generalizability of results to non-participating parents. Second, this study was conducted under a global COVID pandemic context, the quarantine mandate and fear of virus transmission may contribute to the relatively low enrollment and participation rates in intervention sessions and in-person data collection for MVPA, height, weight, and % body fat among parents. Moreover, the potential additional stress that parents had encountered during the pandemic may have lowered the intervention effects. Thus, caution is needed when interpretating the results, especially their generalizability to a different social context. Third, we could not possibly control for every potential sociodemographic and lifestyle factor and the self-reported nature and short form of some measurements leave the possibility of residual confounding. In addition, the study sample size was small due to the challenging recruitment under a global pandemic context although we managed to oversample 10 daycare centers instead of the originally planned 6, a small ICC of 0.01 was used in power analysis, the significant level was not adjusted for multiple comparisons when examining all outcomes, and potential confounders were not controlled for during the analyses, which may threaten the statistical conclusion validity and increase the risk of false negatives. Finally, the study did not include a long-term follow-up evaluation, so future research should focus on assessing the long-term sustaining effects of the intervention.

Conclusions

The positive impacts of the dyadic *FirstStep2Health* intervention on parents are promising. In addition to the improvements in parental knowledge and self-efficacy, the intervention's contributions to improving parenting style and feeding practices as well as their anthropometric and cardiovascular outcomes (slowed the decreases in BMI and % body fat, decreased systolic and diastolic BP) are vital given the detrimental impacts of obesity-related comorbidities (e.g., hypertension, type 2 diabetes, cardiovascular diseases, and cancers) in the U.S. The dyadic intervention's positive effects on improving both children and parents' outcomes [23] further imply the bidirectional and intergenerational relationships within a family system. Therefore, dyadic interventions targeting both children at school and parents at home may have created a virtuous cycle, enhancing parents' supportive influences on children's behaviors and children's positive impact on parenting practices [49]. Future endeavors should proactively engage parents in childhood obesity prevention efforts and evaluate the effects among both children and parents.

Table 1. The dyadic *FirstStep2Health* intervention for parent-child dyads

Component	Purpose	Description
Daycare-based child program	Increase knowledge and skill on healthy eating and physical activity	Children received weekly, age-appropriate, participatory learning sessions delivered by trained interveners on mindful eating (learning/tasting fruits/vegetables using five senses) and physical activity (practicing fun animal movements and activity games including yoga stretching movements and relaxing breathing activities). The program included two sessions per week, and each session lasted about 20 minutes.
Child letters	Connect school learning with home practice	Each week, children created two letters using stickers regarding a food or activity presented in the daycare-based program that they liked or wanted to try at home. Letters were sent privately to each parent via Facebook messenger or text messaging every Wed. and Fri. Parents were encouraged to discuss letters with their children and offer foods and activities desired by children. Parents were also asked to answer two Facebook multiple-choice questions related to the letters each week by Sun. midnight (a. What foods listed in your child's letter did you provide? b. What activities listed in your child's letter did your family try?).
Social media-based parent program	Foster a healthier home environment	Provided parents a weekly electronically retrievable flyer containing health information, family fun activities, and behavioral change strategies to help create a healthier home environment and encouraged interactive positive communication to promote peer support. Parents were asked to post a message or a picture on healthy eating and physical activity, positively respond to other parents' postings, and complete a 2-question quiz each week to reinforce information and strategies learned in the weekly flyer.
Parent group meetings	Promote behavioral change strategies	Three virtual meetings via zoom at week 1, 8 and 16, each meeting lasted about an hour. **Meeting 1**: program orientation, heathy cooking. **Meeting 2**: MyPlate plates, food labels, smart shopping. **Meeting 3**: program overview, community healthy eating and PA resources (e.g., farmer's markets, community gardens, nearby parks or other free or affordable PA facilities).
Motivational text messages	Increase parental motivation	Every week, three motivational text messages were sent at noon on Monday, Wednesday, and Friday to focus on parenting/family and lifestyle changes. For example, "*If there is anything that we wish to change in our children, we should first examine it and see whether it is not something that could better be changed in ourselves*."

Table 2. Study outcomes and measures

Outcome	Measure	Subscales	# Items	Example Question	Reliability/Validity in Literature	Cronbach's a in this study
Screen time	NHANES-Physical Activity and Physical Fitness Survey [50]	N/A	1	Over the past 30 days, on average how many HOURS per day did your child sit and watch TV or videos, or play video or computer games?	Reliability: *r*=0.63-0.84 [51]	N/A
F/V and fiber intake	Fruit-Vegetable-Fiber Screener [52]	F/V intake, fiber intake	10	How often do you eat green salad?	r=0.71 with full Block survey [52]	0.78
Knowledge	Knowledge On Preschoolers' Dietary Intake & Physical Activity [53]	Nutrition knowledge, physical activity knowledge	25	Food serving sizes are the same for children and adults.	N/A	N/A
Self-efficacy	Parental Self-Efficacy Scale [53]	Nutrition self-efficacy, physical activity self-efficacy	20	On a scale from 1-10, how confident are you that you can plan regular safe, but fun physical activity for your child?	a=0.72-0.75 [53]	0.95
Parental support	Parental Support Scale For Eating Habits And Physical Activity [54]	Nutrition parental support, physical activity parental support	12	During the LAST WEEK, how did you offer healthy foods to your child?	a=0.83-0.87 [55]	0.84
Parenting style	Parenting Style and Dimensions Questionnaire [56]	Authoritative, authoritarian, permissive parenting style	32	I allow my child to give input to family rules.	a=0.64-0.91 [57]	0.82
Parent feeding practices	Child Feeding Questionnaire [58]	Perceived responsibility for child feeding, perceived parent weight status, perceived child weight status, concerns about child weight, restrictions of child's access to food, pressure to ask child to eat more, monitoring of child's eating	28	If my child says "I'm not hungry," I try to get her to eat anyway.	a=0.71-0.93 r=-0.26-0.53 with child BMI [59]	0.75
Home environment	Family Nutrition and Physical Activity screening tool [60]	Home eating environment, home physical activity environment	20	How often does your child eat while watching TV (Includes meals or snacks)?	Correlated with child BMI [61]	0.82

Table 3. Demographic characteristics of parents

Variable	Total (*N*=95)		Intervention (*n*=53)		Control (*n*=42)		Mixed-effect model	
	N (mean)	*% (SD)*	*N (mean)*	*% (SD)*	*N (mean)*	*% (SD)*	*B/OR*	p-value
Age (years, 21-48)	30.42	5.73	30.74	6.11	30.02	5.27	.98	.440
Sex							1.02	.938
Female	87	91.6	48	90.6	39	92.9		
Male	7	7.4	4	7.5	3	7.1		
Other	1	1.1	1	1.9	0	0		
Ethnicity							1.03	.828
Hispanic	8	8.4	3	5.7	5	11.9		
Non-Hispanic	87	91.6	50	94.3	37	88.1		
Race							1.38	.071
White	44	46.3	18	34	26	61.9		
Black	35	36.8	23	43.4	12	28.6		
Mixed race	9	9.5	6	11.3	3	7.1		
Other	7	7.4	6	11.3	1	2.4		
Marital status							.89	.411
Married/partnered	36	37.9	23	43.4	13	31		
Separated/widowed	5	5.3	3	5.7	2	4.8		
Single	54	56.8	27	50.9	27	64.3		
Annual family income							1.19	.305
< $20,000	63	66.3	32	60.4	31	73.8		
$20,000-$29,999	15	15.8	8	15.1	7	16.7		
$30,000-$49,999	16	16.8	13	24.5	3	7.1		
≥ $50,000	1	1.1	0	0	1	2.4		
Employment status							1.01	.932
Full-time	23	24.2	13	24.5	10	23.8		
Part-time	25	26.3	13	24.5	12	28.6		
No	47	49.5	27	50	20	47.6		
Education level							1.05	.743
< high school	15	15.8	9	17	6	14.3		
High school	40	42.1	22	41.5	18	42.9		
Some college	29	30.5	13	24.5	16	38.1		
Technical/community college	10	10.5	8	15.1	2	4.8		
Bachelor's degree	1	1.1	1	1.9	0	0		
Number of children							.90	.428
1 child	18	19.2	10	18.9	8	19.5		
2 children	30	31.9	17	32.1	13	31.7		
3 children	22	23.4	13	24.5	9	22		
4 children	13	13.8	8	15.1	5	12.2		
≥ 5 children	11	11.7	5	9.4	6	14.6		
Missing	1	1.1	0	0	1	2.4		

Table 4. Descriptions of parents' outcomes over time

Outcome	Intervention				Control				Effect Sizes and 95% CI		
	Baseline		Post-Intervention		Baseline		Post-Intervention				
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Cohen's d*	*LL*	*UL*
Nutrition knowledge (n=95)	6.72	1.34	7.45	1.27	7.24	1.46	6.68	1.87	**.86**	.44	1.29
Physical activity knowledge (n=95)	12.02	1.50	12.53	1.64	12.19	1.73	11.58	2.42	**.51**	.10	.92
Nutrition self-efficacy (n=95)	8.36	1.51	8.95	1.35	8.16	1.55	8.18	1.68	.37	-.04	.78
Physical activity self-efficacy (n=95)	8.59	1.58	9.27	1.12	8.56	1.33	8.38	1.70	**.47**	.06	.88
Nutrition parental support (n=94)	4.12	.91	4.52	.80	4.17	.98	4.39	.71	.21	-.19	.62
Physical activity parental support (n=94)	4.71	1.26	5.15	1.05	4.55	.96	4.64	1.25	.25	-.16	.66
Parenting style (n=94)											
Authoritative	4.20	.48	4.35	.52	4.02	.72	4.0	.76	.27	-.14	.67
Authoritarian	1.64	.48	2.46	1.24	1.63	.45	2.78	.91	-.30	-.70	.11
Permissive	2.40	.80	2.16	.84	2.26	.69	2.41	.88	**-.49**	-.90	-.08
Parent feeding practices (n=95)											
Feeding responsibility	4.67	.52	4.65	.71	4.59	.66	4.58	.64	-.01	-.87	.39
Perceived parent weight	3.14	.36	3.11	.43	3.15	.41	3.31	.46	**-.46**	-.87	-.05
Perceived child weight	2.97	.29	2.95	.32	2.93	.25	2.88	.29	.11	-.30	.52
Concern about child weight	1.46	.82	1.46	1.05	1.20	.31	1.13	.26	.09	-.32	.50
Restriction	3.54	.74	3.33	.86	3.54	.74	3.37	.87	-.05	-.46	.35
Pressure to eat	3.13	1.0	2.86	.99	2.79	.84	2.68	.80	-.16	-.56	.25
Monitoring	4.21	.82	4.04	1.10	3.82	1.21	4.13	.83	-.39	-.80	.02
Home eating environment (n=94)	30.94	4.24	31.68	4.13	30.74	3.52	30.74	4.07	.19	-.22	.59
Home physical activity environment (n=94)	30.52	5.07	31.24	4.78	28.74	4.59	28.42	4.71	.21	-.19	.62
Behavioral Outcomes											
Physical Activity											
Light (min/hour, n=42)	17.89	3.77	15.72	9.19	19.03	8.27	14.43	9.17	.23	-.18	.63

MVPA (min/hour, primary outcome, n=42)	15.98	7.48	8.25	6.75	14.48	6.95	10.14	9.77	-.36	-.77	.05
Diet Quality											
F/V intake (servings/day, n=95)	3.39	1.93	4.52	2.46	2.95	2.03	3.44	1.58	.25	-.15	.66
Fiber intake (servings/day, n=95)	14.31	5.66	17.52	7.26	12.69	5.93	14.03	5.12	.26	-.14	.67
#Skin carotenoids (n=20)	256.33	55.88	252.63	41.61	236.83	50.14	250	44.2[illegible]	-.25	-.65	.16
Screen time (hours/day, n=95)	6.40	5.29	4.93	4.71	7.38	6.18	5.93	5.67	-.003	-.41	.40
Physical Outcomes											
BMI (n=58)	29.55	8.32	31.3	8.37	32.43	9.51	33.58	8.91	-.34	-.74	.07
% body fat (n=55)	36.07	9.01	37.42	6.58	39.28	10.85	41.8	8.3	-.32	-.73	.09
Systolic BP (n=57)	122.53	18.69	120.98	21.12	117.05	9.02	129	17.2[illegible]	**-1.11**	-1.54	-.67
Diastolic BP (n=57)	75.14	13.39	77	14.88	75.98	6.49	82.44	9.41	**-.58**	-.99	-.17
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*[b]OR*	*LL*	*UL*
Proportion of OW/B (n=58)	23	69.7	23	79.3	13	61.9	16	80	.96	.23	3.95

Note. [a]Cohen's d was calculated using mean difference and the standard deviation of the mean difference in each group (62), and positive values indicate the intervention group had a mean increase from baseline to post-intervention when comparing to the control group. [b]OR was calculated using the post-intervention OW/O rate in each group. #Skin carotenoids were measured only in the study Year 2 among 20 parents using Veggie Meter; SD=standard deviation; BMI=body mass index; F/V=fruits/vegetables; MVPA=moderate to vigorous physical activity; OW/O=overweight/obesity; OR=odds ratio; CI=confidence interval; LL=lower limit; UL=upper limit.

Table 5. Intervention effects on parents' outcomes after adjusting for random cluster effects of daycare centers and classrooms

Outcome	*B*	*95% CI for B*	*p-value*
Nutrition knowledge	.87	.23, 1.52	**.009***
Physical activity knowledge	.95	.002, 1.89	**.049***
Nutrition self-efficacy	.74	.09, 1.39	**.025***
Physical activity self-efficacy	.86	.19, 1.53	**.013***
Nutrition parental support	.27	-.05, .58	.099
Physical activity parental support	.53	-.01, 1.07	.055
Parenting style			
Authoritative	.27	-.01, .55	.060
Authoritarian	-.28	-.81, .25	.292
Permissive	-.27	-.62, .09	.139
Parent feeding practices			
Feeding responsibility	.06	-.27, .40	.702
Perceived parent weight	-.17	-.35, .02	.081
Perceived child weight	.04	-.08, .17	.502
Concern about child weight	.22	-.14, .58	.233
Restriction	-.03	-.38, .33	.879
Pressure to eat	.13	-.28, .55	.526
Monitoring	-.18	-.67, .30	.448
Home eating environment	.67	-1.04, 2.38	.439
Home physical activity environment	1.91	-.19, 4	.073
Proximal Behavioral Changes			
Physical Activity			
Light (min/hour)	4.06	-3.98, 12.10	.308
MVPA (min/hour, primary outcome)	.49	-5.82, 6.81	.874
Diet Quality			
F/V intake	1.0	-.01, 2.01	.051
Fiber	2.99	.02, 5.97	**.049***
#Skin carotenoids	32.16	-40.41, 104.72	.330
Screen time (hours/day)	-.84	-3.38, 1.70	.512
Distal Anthropometric Outcomes			
BMI	-.77	-1.94, .40	.191
% body fat	-2.56	-4.29, -.84	**.005***
Systolic BP	-10.98	-18.31, -3.64	**.005***
Diastolic BP	-2.78	-8.86, 3.31	.360
	OR	*95% CI for OR*	*p-value*
Proportion of OW/B	1.77	.04, 87.5	.769

Note. *$p \leq .05$; #Skin carotenoids were measured in the study Year 2 among 20 parents using Veggie Meter; B=unstandardized regression coefficient; CI=confidence interval; BMI=body mass index; F/V=fruits/vegetables; MVPA=moderate to vigorous physical activity; OW/O=overweight/obesity; OR=odds ratio.

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