

A Mindful Movement Program in Community and University Preschools: A Pilot Randomized Controlled Trial Study Protocol

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Abstract

Background: Chronic stress and emotional and cognitive regulation difficulties during early childhood are associated with risky behaviors and negative outcomes later in life. As preschoolers are still developing their emotional and cognitive regulation skills, they often depend on external support to manage their emotions and behaviors. Intervening early is essential for promoting healthy development and preventing future challenges. Mindful Movement Practices (MMPs) – which incorporate physical activities, breathwork, and reflective exercises – show potential in enhancing emotional and behavioral regulation. The impact of MMPs on cognitive and social-emotional development in young children, however, has not been thoroughly researched and the mechanisms behind these effects remain unclear.

Objective: This pilot randomized controlled trial (RCT) aims to assess the feasibility and acceptability of implementing MMPs in preschool classrooms and explore their effects on preschoolers' social-emotional, cognitive, and physiological development. The study also focuses on enhancing prosocial behaviors and reducing problem behaviors. This protocol paper outlines research procedures, sample demographics, and survey data psychometric properties.

Methods: The study was conducted in three preschool classrooms (two intervention and one waitlist control). Data were collected among 32 children and 8 teachers. Before the study began, eight formative focus groups were facilitated with 5 administrators and 32 teachers in total to inform modifications to the program and research design. The intervention group participated in 16 weeks of programming, including neural-based drills, aerobic activities, breathwork, and “feelings circle” exercises, along with classroom and home kits. The waitlist control group received a shortened (8-week) program after the intervention groups completed their sessions. Data were collected before and after the intervention and again 2 months post-intervention. Measures included behavioral tasks, biomarkers (heart rate variability via wearable sensors and hormonal substrates in hair), and surveys from parents and teachers. Implementation fidelity was assessed using quantitative logs, qualitative field notes, and video observations. Post-intervention interviews and focus groups were conducted with teachers, parents, and administrators.

Results: Formative focus groups were conducted with 32 teachers, 5 administrators. Data were collected from 40 participants, including 32 preschoolers (ages 3-5 years, $M = 4.4$) and 8 teachers with a mean age of 37.9 years. Post-intervention interviews and focus groups were completed with 7 teachers, 4 administrators, and 8 parents.

Conclusions: This paper describes study procedures. Future publications will present primary outcome findings and evaluate the feasibility and acceptability of this MMP and research design in community-based and university-based preschool settings. Future papers will provide evidence for the program's effectiveness, mechanisms of effects, and the need for larger randomized controlled trials to optimize early childhood mindfulness interventions.

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Original Manuscript

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Keywords: mindfulness; mindful movement practices; preschool children; early childhood; emotional regulation; stress response; randomized control trial; social-emotional learning

Introduction

Background

Chronic stress is an increasing public health concern that frequently originates in early childhood, particularly among vulnerable populations [1,2]. Persistent stress during early childhood can lead to emotional and cognitive dysregulation, which may later result in risky behaviors during adolescence, including substance abuse, violence, delinquency, and unsafe sexual practices [3-5]. Such outcomes contribute to substantial social and economic burdens in adulthood, manifesting as increased interactions with the criminal justice system, addiction, unemployment, and various health issues [6-8]. Early childhood is a crucial time period to develop positive coping strategies via implementation of evidence-based interventions designed to foster positive trajectories in life.

Preschool years are a pivotal period for the maturation of brain regions associated with motor function, self-regulation, cognition, language, and social competencies [9]. The developmental changes occurring in early childhood present an optimal opportunity for intervention, with preschool environments serving as ideal settings for such initiatives. Mindful Movement Practices (MMPs), which incorporate movement patterns, attention-focused exercises, breathwork, and static postures, provide effective self-regulation strategies for young children [10-12]. These practices leverage sensory-motor systems, cognitive control, and emotion regulation to assist children in managing stress and emotional responses [13,14]. Furthermore, the social-emotional learning (SEL) components inherent in MMPs foster positive emotional and behavioral development in children. While most school-based mindfulness research has focused on adolescents, findings show limited effects on externalizing behaviors (e.g., aggression) and modest impacts on internalizing behaviors (e.g., anxiety) [15-17].

Randomized Controlled Trials (RCTs) are now emerging that investigate the effects of mindfulness in preschool-aged children [18-21] and the implementation of MMPs in early elementary settings [22]. These studies have shown improvements in self-control, motor function,

behavior, executive function, and social-emotional competencies. In addition, MMPs have demonstrated feasibility in urban elementary settings, yielding enhancements in self-control, motor skills, and behavior [22]. Mindfulness practices tailored for preschoolers have also indicated positive outcomes in motor control and social-emotional functioning [18]. These published RCTs show benefits of mindfulness among preschoolers and school-aged children but have not examined which children are most responsive to specific components of MMPs, nor have they explored the underlying mechanisms that contribute to the observed changes. Further research is needed to understand the physiological and social-emotional mechanisms involved in MMP effectiveness as well as which elements of MMPs are most effective for diverse children. In response to this gap, we conducted a pilot RCT to evaluate the hypothesis that MMPs could alter preschoolers' behavioral difficulties by impacting physiological, social-emotional and cognitive factors.

Objectives

This pilot study was designed to lay the groundwork for a larger RCT utilizing the mindful movement program (MMP) and building an evidence base to support broader dissemination of an effective, low-cost, highly scalable program. This pilot study has three primary aims:

1. *Feasibility and Acceptability*: Assessing the practicality and reception of the intervention and research procedures among preschoolers, teachers, parents, and administrators, as well as evaluating the acceptability of data collection methods, including physiological, behavioral, qualitative, and survey measures.
2. *Effects on Mechanisms and Outcomes*: Investigating how the sequential implementation of MMP components influences self-regulatory capacities, SEL skills, problem behaviors, and prosocial behaviors, and identify underlying physiological mechanisms of program effects.
3. *Teacher Effects*: Evaluating how exposure to MMPs affects teachers' stress responses and classroom dynamics, which may subsequently enhance child outcomes.

Method

Setting

Two sites – one community-based (2 classrooms) and one university-based (1 classroom) – participated in the study. These sites were chosen because they serve families from the local community. Site 1 (community-based Head Start) had eight and Site 2 (university-based pre-school) had three active preschool classrooms. Site 1 receives federal funding to provide early childhood education for children from families living below federal poverty guidelines or facing other stressors such as homelessness or disability. Of the enrolled families, 90% are low income and 14% receive public assistance [23]. Enrollment is determined by need. According to a county-level report for all Head Start sites in the broader study area, about 11% of children faced homelessness; 14% were referred for developmental disability or special education; and 32% received Supplemental Nutrition Assistance Program (SNAP) benefits. By comparison, an estimated 13% of the United States receive SNAP benefits (Economic Research Service [24]). Site 2 uses an enrollment model that provides a diverse group of children and families. Using a stratified enrollment model, 25% of enrolled children are children of: faculty members, support staff, university students (both undergraduate and graduate), and community families. Approximately 20-30% of the children enrolled come from low-income homes (supported by Child Care Assistance Program subsidy vouchers, a grant supporting childcare needs of low-income undergraduate student parents, and a sliding fee scale).

Participants

A total of 40 participants were enrolled in the study. Participants included 32 preschool children aged 3-5 years ($M=4.4$, $SD=0.63$): 17 (53.1%) female; 11 (34.4%) Black, and 4 (12.5%) Hispanic. Demographics of children are based on parent reports unless those data were missing ($n=4$), in which cases teacher reported values were used. In total, 22 children received the intervention immediately and 10 were assigned to the waitlist control group. Across the three classrooms, eight female teachers participated with a mean age of 37.9 years ($SD=11.47$): 3 (37.5%)

Black, and 4 (50.0%) White. A total of 28 parents completed the demographic questions, with a mean age of 33.5 (SD=6.85): 22 (68.8%) female; 12 (37.5%) Black, and 2 (6.3%) Hispanic. Baseline demographics by intervention group for children and parents are presented in Tables 1-2.

Table 1. Demographic Characteristics of Children

Characteristic	Full Sample (N=32)	Intervention (n=22)	Control (n=10)
Age (years), mean (SD)	4.4 (0.63)	4.6 (0.50)	3.96 (0.70)
Gender, n (%)			
Male ^a	15 (46.9)		
Female	17 (53.1)	10 (45.5)	7 (70.0)
Ethnicity/Hispanic, n (%)			
Not Hispanic/Latinx	28 (87.5)	21 (95.5)	7 (70.0)
Hispanic/Latinx ^a	4 (12.5)		
Race, n (%)			
White	15 (46.9)	11 (50.0)	4 (40.0)
Black or African American	11 (34.4)	6 (27.3)	5 (50.0)
Asian, Native Hawaiian, or	6 (18.7)		
Language, n (%)			
Native English speaker	20 (62.5)	13 (59.1)	7 (70.0)
Disability, n (%)			
None	27 (84.4)	17 (77.3)	10 (100.0)
One or more disabilities	5 (15.6)	5 (22.7)	0 (0.0)

^aEmpty cells indicate samples sizes of less than 4 participants.

Table 2. Demographic Characteristics of Parents

Characteristic	Full Sample (N=32)	Intervention (n=22)	Control (n=10)
Age (years), mean (SD)	33.5 (6.85)	34.8 (5.64)	30.6 (8.55)
Number of kids, mean (SD)	2.2 (1.13)	2.0 (0.77)	2.4 (1.67)
Gender, n (%)			
Male	6 (18.8)	6 (27.3)	0 (0.0)
Female	22 (68.8)	13 (59.1)	9 (90.0)
Missing	4 (12.5)	3 (13.6)	1 (10.0)
Ethnicity/Hispanic, n (%)			
Not Hispanic/Latinx	26 (81.3)	19 (86.4)	7 (70.0)
Hispanic/Latinx ^a			
Missing	4 (12.5)	3 (13.6)	1 (10.0)
Race, n (%)			
White ^a	13 (40.6)		
Black or African American	12 (37.5)	5 (22.7)	7 (70.0)
Asian	4 (12.5)	4 (18.2)	0 (0.0)
Missing	3 (9.4)	3 (13.6)	1 (10.0)

Characteristic	Full Sample (N=32)	Intervention (n=22)	Control (n=10)
Education level, n (%)			
High school degree or GED	9 (28.1)	5 (22.7)	4 (40.0)
Some college but no degree ^a	6 (18.8)		
Associate/Bachelor's degree ^a	6 (18.8)		
Graduate degree	7 (21.9)	7 (31.8)	0 (0.0)
Missing	4 (12.5)	3 (13.6)	1 (10.0)
Marital status, n (%)			
Single living alone ^a	6 (18.8)		
Living with a romantic partner ^a	4 (12.5)		
Married ^a	15 (46.9)		
Separated/divorced ^a	3 (9.4)		
Missing	4 (12.5)	3 (13.6)	1 (10.0)
Employment status, n (%)			
Employed for wages or self-	23 (71.9)	13 (59.1)	10 (100.0)
Unemployed	6 (18.8)	6 (27.3)	0 (0.0)
Missing	3 (9.4)	3 (13.6)	1 (10.0)
Income range, n (%)			
\$26,000 or less ^a	8 (25.0)		
\$27,000-49,000	12 (37.5)	5 (22.7)	7 (70.0)
\$50,000 or more	7 (21.9)	7 (31.8)	0 (0.0)
Missing	5 (15.6)	4 (18.2)	1 (10.0)

^aEmpty cells indicate samples sizes of less than 4 participants, except for reported missingness.

Procedures

This pilot study consisted of formative focus groups (n = 2 administrators, n = 6 teachers) aimed to inform modifications to the study design prior to data collection and implementation. The RCT occurred from January 2024 through August 2024 and consisted of multiple components (detailed below).

Formative Interviews and Focus Groups

In Fall 2023, 6 teachers and 2 administrators participated in formative focus groups at three Head Start locations and the university preschool to gauge teacher and administrator interest in research studies and a proposed intervention study. The majority of teachers were interested in participating. Classrooms were selected based on teacher buy-in and administrator feedback on the feasibility of implementation. The research team followed up with teachers in three identified

classrooms and confirmed their willingness to participate in the research study before classroom selection was finalized.

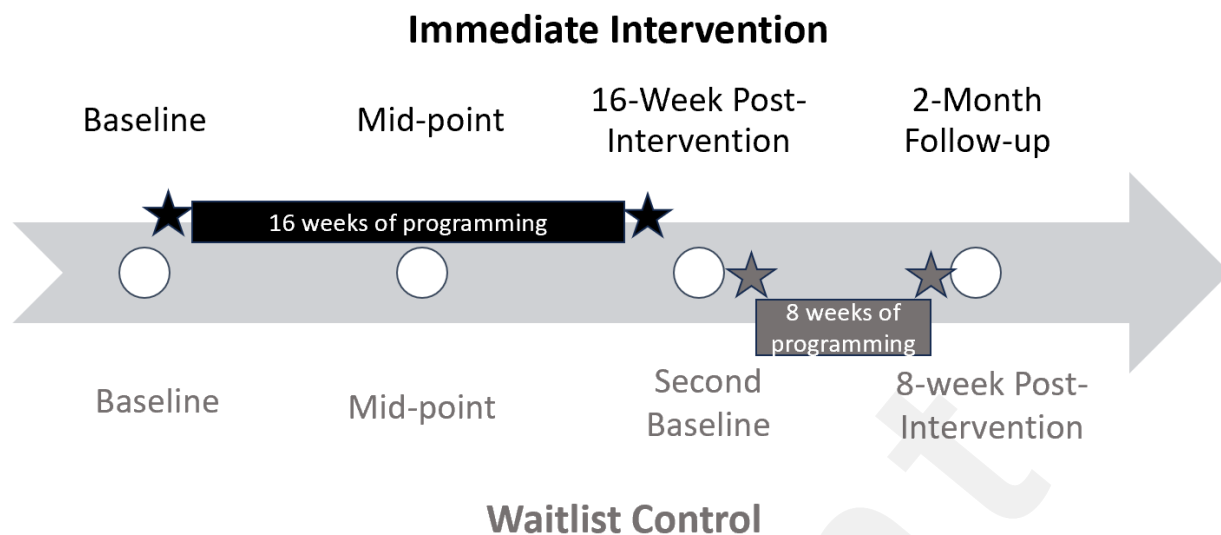
Randomization Procedures

At site 1, two classrooms were randomly assigned to receive the 16-week intervention or serve as waitlist control group. Randomization was conducted by writing classroom numbers on pieces of paper, which were then folded, mixed, and one was drawn to assign the intervention group. The one classroom at site 2 was assigned to receive the 16-week intervention. A two-to-one ratio between the intervention and control groups was chosen to maximize the number of children receiving the intervention while maintaining a comparison group for evaluating the effectiveness of the program.

Data Collection Timeline

Data were collected at four time points: baseline (pre-intervention; all classrooms), mid-intervention (8-weeks into programming; all classrooms), post-intervention (immediately following the 16-week intervention or waitlist period; all classrooms), and 2-month follow-up (two months after post-intervention; one intervention classroom). In the waitlist control group, the post-intervention also served as their second baseline and the 2-month follow-up served as their post-intervention (immediately after the 8-week intervention). The data collection timepoints are illustrated in Figure 1 by intervention (black) and waitlist control (grey) groups. At each timepoint, survey data were collected electronically (in-person or online) or via paper-and-pencil, whichever was feasible and preferred by participants. Behavioral assessments were administered at all timepoints except for mid-intervention.

Figure 1. Overview of Data Collection Timepoints by Experimental Group



The Mindful Movement Program

The MMP combines movement practices (Mission2Move [25]) and positive behavioral intervention supports Calm Caterpillar [26]) into one program, referred to as M2M-CC for short. M2M-CC integrates evidence-based movement (Z-Health; [27]) and meditation (Mindful Schools; [28,29]) strategies. It is a social emotional learning program that provides a mindful movement curriculum and tools to support classrooms and child development. M2M-CC practices include (a) neural-based drills, (b) aerobic activity, (c) breathwork and guided meditation, and (d) “feelings circle” or reflective practices. Positive behavioral intervention occurs with the use of visual and tactile aids and supports are provided through (e) classroom/ home kits that children, parents, and teachers can utilize in times when children need assistance in regulating their emotions and behaviors. The movement (a & b) and mindfulness (c & d) practices work in conjunction with each other to teach children how physical health is tied to social-emotional well-being and goal attainment [30]. Teachers and parents receive a calm corner kit (e) near the end of the program to help children practice self-regulation techniques at home and in the classroom when direct instruction is not occurring.

Program Implementation

For the study, the program was delivered twice per week in classrooms receiving the intervention. One weekly session was a 15-minute mindful movement class [MM class] and the other session was a 5–7-minute refresher/booster class. These classes were taught over 16 weeks (immediate intervention group) and eight weeks (waitlist control). Before programming began, teachers received professional development training. During programming, teachers were present for direct instruction by study implementers so they could learn the mindful movement practices for future classroom implementation.

A four-part sequence of program components was administered over time. First, children warmed up with *neural-based drills*. Drills use specific movements to train the nervous system in how body parts are supposed to move. These increase children's body awareness in movement, location, and action (i.e., proprioception). Neural drills included movements such as hip circles or ankle tilts. In addition to neural drills, children were led in aerobic movement-focused activities (e.g., dance; running in place). Second, children learned a variety of *simple breathing practices* that used different techniques for varied benefits. For example, children learned hand breathing – inhaling and tracing up a finger, then exhaling and tracing down a finger – to self-calm. Third, engaged in a reflective practice known as “*feeling circles*” where they talked about the meaning of different feelings and shared when they experienced the feeling. We used a “talking stick” approach whereby each child had the opportunity to share and be heard when they held the stick. Last, classrooms and parents were provided a kit of tools for creating a calming corner (positive behavioral intervention supports: PBIS) to reinforce skills taught in the program.

As shown in Table 3 (based on 15-minute mindful movement class), mindfulness program components were sequentially introduced one-quarter of the time after the first component. For example, during a 16-week implementation, components were added every 4 weeks (weeks 1-4, 5-8, 9-12, 13-16). In an 8-week long administration, program components were added every 2 weeks.

Movement was first introduced, then breathwork and meditation, then feeling circles/ reflection, and last the calm corner (PBIS). This allowed for assessing program component effects on physiological (i.e., respiratory sinus arrhythmia and vagal efficiency) and SEL mechanisms.

Table 3. Programming Component Description, Impact, and Implementation Details

Component	Description	Hypothesized Impact	Timing	Weeks	Modality	Where	How
Neural Drills	Activate brain through specific body movements (e.g., hip & arm circles)	Learn body awareness & inhibitory control	5 min	1-16	Movement	School	Direct Instruction
Aerobic Activities	Elevate heart rate via different activities and movement sequences	Reduce overall stress and cortisol	10 min	1-16	Movement	School	Direct Instruction
Breathwork & Meditation	Practice breathing techniques (e.g., hand, belly, lion's breath, body scan meditation)	Practice control over emotions	2-3 min	5-16	Mindful	School	Direct Instruction
Feelings Circles	Label feelings and share personal examples with the circle; emotion recognition	Practice reflection, learn empathy and interpersonal connection	2-3 min	9-16	Mindful	School	Direct Instruction
Calming Corner	Kit given to classrooms and parents; quiet space with reduced stimuli; visual aids to self-calm; tactile weighted toy for soothing and counting; down-regulation strategies for children	Practice self-calming skills; removed from stimulation	varies	13-16+	Positive Behavioral Intervention Supports	School & Home	Child & adult self-guided

Waitlist Control Procedures

For consistency of exposure to research team personnel, both the immediate intervention and waitlist (WL) classrooms were visited by the implementation team twice weekly for 20 minutes per week. For the WL classroom, implementers interacted with children during typical classroom activities (e.g., reading, playing with sensory tables).

Following the 16 weeks of programming and post-assessments, the WL group received eight weeks of the MMP with each program component sequentially added every two weeks. This condition allowed for testing short compared to longer program dosage effects.

Outcome Measures

Behavioral Assessments

The *Pencil Tapping Task* assesses working memory and inhibitory control [31,32]. In this task, both the evaluator and the child held a pencil in their dominant hand. The child was instructed to tap the pencil twice when the evaluator taps once and to tap once when the evaluator taps twice. This required the child to hold the rules in working memory while inhibiting the natural tendency to mirror the evaluator's tapping pattern. Up to six practice trials were used before the official assessment began. During the practice trials, the evaluator provided feedback on correct and missed trials to ensure understanding of the task. Following the practice trials, 16 scored trials were administered without feedback. The total number of correct responses ranges from 0-16.

The *Gift Delay Task* assesses self-regulation [33]. In this study it also served as a stress task to assess child coping and stress response (e.g., behavioral and physiological via heart rate variability, RSA, and vagal efficiency). During this task, the child sat at a table while the experimenter presented a gift bag containing a prize but explained that the bag needed a bow before the child could open it. The experimenter placed the bag in the center of the table and instructed the child to remain seated and not touch the bag until she returned. After a 3-minute delay, the experimenter returned, placed the bow on the bag, and gave the child the gift, regardless of whether they followed the instructions. Scoring is based on the child's ability to resist the temptation to touch the gift bag during the waiting period. Children were scored a "1" if they took the gift from the bag, "2" if they put their hand in the bag, "3" if they peeked in the bag, "4" if they touched the bag, and a "5" if they followed all instructions. Scores range from 1 to 5. Time spent out of the seat was also

calculated and categorized into four distinct levels: “1” for less than 30 seconds in seat to “4” for more than 2 minutes in seat. A final seat score was computed by assigning an additional $\frac{1}{2}$ point for each minute a child spent out of seat within arm’s reach of the table for those with scores of “1” or “2”. The task was video-recorded using a discreet camera for later review and double scoring by a second researcher.

The *Tower Task* assesses turn-taking and inhibition [33]. During this task, the child sat at a table and the experimenter sat across from them. The child was given a practice trial where they were instructed they would be building a tower together by taking turns. First, the experimenter placed a block on the table and instructed the child to place the next block on top. The practice trial ended after the tower was six blocks tall. During the practice trial they were reminded to take turns if they were not taking turns. The actual trial consisted of 12 blocks and the experimenter told the child they would build a really tall tower together and the child could go first. Children were scored on two characteristics. First, on turn-taking: “0” no turns (child built it by themselves), “1” partial turn-taking, or “2” full turn-taking. A second turn-taking score was calculated based on the proportion of blocks placed by the experimenter (multiplied by 10) relative to the total number of blocks placed. The child received the highest score if they alternated placing blocks equally with the experimenter. A penalty of 5 points was applied if the child knocked the tower over, while an additional 5 points were awarded if the child gently removed blocks from the tower during cleanup. Children were given two minutes to clean up the tower and were scored a “2” if they cleaned up the towers on first try, “1” if they needed follow-up after one minute, or “0” if they did not clean up the tower.

The *Go/No-Go Task (GNG) Task* assesses inhibitory control in young children [34-38]. In our study, we used an app-based version of the GNG task on an Apple iPad. Children were tasked with catching fish (go trials) and avoiding sharks (no-go trials) as they moved across the screen [39]. To enhance the dominant response and increase the difficulty of inhibiting responses during the "no-go" trials, 80% of the trials were "go" and 20% were "no-go" trials. Before starting, children received

instructions on both trial types and practiced five trials of each. This was followed by a mixed block of 10 practice trials (with 80% "go" trials). A brief review of the instructions was provided before the task began. The main task consisted of 75 test stimuli, evenly distributed across three blocks. The stimuli were presented in pseudo-random order, ensuring that no block began with a "no-go" trial, and that no more than two consecutive "no-go" trials occurred. A 1,000 millisecond (ms) interval was maintained between stimuli. Scores were calculated by first excluding trials with response times shorter than 300 ms, as these were considered non-task-related. Next, blocks were removed if the child demonstrated nonresponsiveness (i.e., go trials < 20% accuracy or no-go trials > 80% accuracy) or indiscriminate responding (i.e., go trials > 20% accuracy and no-go trials < 20%). The impulse control score, which reflects the ability to withhold a response in the presence of a strong, automatic tendency to respond, is calculated by multiplying the percentage of correct "go" responses by the percentage of correct "no-go" responses.

Biomarkers

Data were collected to assess potential physiological mechanisms driving the intervention effects. These mechanisms were evaluated across several biological systems: the autonomic nervous system (ANS), the hypothalamic-pituitary-adrenal (HPA) axis, and the hypothalamic-pituitary-gonadal (HPG) axis. These systems were chosen because they play key roles in self-regulation and the body's response to stress and challenge or threat [40].

Heart Rate Variability (HRV).

Heart rate variability (HRV) assesses acute stress response and reflects the balance between the sympathetic nervous system (SNS) and parasympathetic nervous system (PNS), both of which are integral to maintaining homeostasis [41]. HRV is a well-established biomarker of an individual's ability to regulate and recover from stress [42].

For teachers and children who opted into this component of data collection, HRV data were

collected at multiple time points: prior to the intervention, every four weeks during implementation (with each new module), and at post-intervention and 2-month follow-up assessments. To collect HRV data, trained research assistants attached Firstbeat™ Body Guard sensors (Firstbeat Technologies Ltd, Jyväskylä, Finland; [43]) to the participants—both children and teachers—by placing them beneath the right collarbone and connecting the sensor cable to the rib cage on the opposite side [44]. If a participant had sensitivities to its placement on the front of the body, electrodes were placed in these equivalent locations on the back. The sensors were then removed once data collection was complete.

HRV Collected During Implementation.

For children, the baseline HRV was measured while they were sitting still or engaged in low-physical movement during class activities for approximately 3-5 minutes. During each program module, HRV was measured in both the active and recovery states, with sensors worn for around 20 minutes during the program implementation days. Teachers wore the sensors at the same time points as the children, both before and after the program, during normal classroom activities, and for the same amount of time as the children during the program.

HRV Collected During Behavioral Tasks.

Children wore Firstbeat™ sensors while completing all of the tasks, especially the Gift Delay Taska task designed to induce moderate psychological stress. This task, commonly used in research to provoke a physiological stress response [45,46], was collected prior to the intervention, post-intervention, and 2-month follow-up. The task sequence involved three phases. First, there was a 3-minute baseline phase where children colored quietly to establish a baseline HRV measurement. This was followed by a 3-minute Gift Delay Task, which was intended to evoke the stress response. Finally, this was followed by a 3-minute recovery phase, where children had time to recover after the stressor. Throughout the paradigm, heart rate and pulse wave activity were continuously monitored to assess changes in vagal tone, allowing for the measurement of both reactivity (the body's immediate

response to stress) and recovery (how well the body returns to baseline following stress). This procedure – baseline, task, recover – was followed for the pencil tapping, tower building tasks, Go/No-Go task as well even though they were not hypothesized to elicit the same stress response as the Gift Delay Task.

Hormone Measurements.

Hair was collected to measure cortisol, testosterone, and Dehydroepiandrosterone (DHEA) levels to capture chronic stress and threat-challenge exposure. Cortisol, a hormone secreted by the HPA axis, is known to rise in response to stress [47]. Testosterone, produced by the HPG axis, also increases in response to challenging situations [48,49]. DHEA is closely linked to both cortisol and testosterone and is needed to tease out the unique coupling effect. DHEA is produced adrenally in both the gonads and the brain. DHEA and its sulfated analog DHEA-S are the most abundant hormones in the body, and as an adrenal androgen, DHEA operates as an end-product of both HPA and HPG axes [50]. By examining the coupling of HPA and HPG axis activity, both independently and together, we can better predict the risk of negative health outcomes related to stress [51]. Additionally, exploring HPA-HPG coupling broadens the understanding of stress from the traditional “fight-or-flight” response to a more nuanced “threat-challenge” framework, which can apply to a wider range of real-world stressors [48,52].

Hair samples were collected from both children and teachers who consented to participate in this component of the study. These samples were used to assess cortisol, DHEA, and testosterone levels, as hair is highly sensitive to hormonal changes. Hair sampling is more feasible than saliva collection in preschool-aged children and hormone measurement is more reliable in hair than fingernail clippings. Hair samples were collected at three time points: pre-intervention, post-intervention, and at a two-month follow-up. A 1 cm section of hair reflects approximately one month of growth. Therefore, with hair lengths of several centimeters, we are able to assess change of time in hormonal activity, with the closest hair to the scalp representing the most recent hormone

accumulation [53,54].

Trained research assistants cut a small section of hair, containing around 50-100 strands, from the posterior vertex of the participant's scalp following standardized hair sampling procedures [53]. If necessary, multiple small samples from the same region were collected to ensure sufficient hair for analysis. The samples were preserved in foil and envelopes, labeled with the date and participant ID. Family members were also given the option to provide hair samples on-site or, follow instructions to cut them at home. The research team made efforts to accommodate different preferences for hair sample collection.

Surveys

Surveys containing standardized questionnaires were completed by parents and teachers either via paper-and-pencil or electronically via Qualtrics (Qualtrics, Provo, UT), depending on preference and availability. Lead and assistant teachers completed surveys about themselves (self-report) and lead teachers completed surveys about each child in their classroom. Parents completed surveys about their children and a self-report survey about their perceived stress. See Table 4 for the list of survey questionnaire and scales collected at each timepoint and by respondent. Published scoring guidelines were used for all standard scales. and questionnaires.

Table 4. List of survey assessments and time points collected during the study.

Report Type	Category	Measure	Respondent	Time point
Report on Children	Sociodemographic	Age, sex, race/ethnicity, disabilities, home language, language proficiency	Parent & Teacher	Pre-
	Adversity	Adverse Childhood Experiences Questionnaire	Parent	Pre-
	Social-emotional behavior	- Children Behavior Questionnaire – Very Short Form - Strengths and Difficulties Questionnaire - Open-ended questions	Parent & Teacher	Pre-, post-, F/U
	Relationship and implicit bias	- Students-Teacher Relationship Scale-Short Form - Preschool Expulsion Risk Measure - Open-ended questions	Teacher	Pre-, post-, F/U
Self-report	Sociodemographic	Age, sex, race/ethnicity, highest level of education achieved, household income, marital status, employment status, number of kids, teachers' role ^a	Parent & Teacher	Pre-
	Stress level	Perceived Stress Scale	Parent & Teacher	Pre-, post-, F/U

Report Type	Category	Measure	Respondent	Time point
	Teachers' changes	- Teacher Social Emotional Learning (SEL) Beliefs Scale - Mindfulness in Teaching Scale	Teacher	Pre-, post-, F/U

^a Only from the teacher's report; F/U = follow-up

Teacher Report on Child.

Children who had parental consent were rated by lead teachers on preschool expulsion risk, student-teacher relationship quality, behaviors, and strengths and difficulties.

The *Preschool Expulsion Risk Measure (PERM)* was used to measure implicit bias [55]. This 12-item scale includes four subscales with three items each - classroom disruption, fear of accountability, hopelessness, and teacher stress. Items are rated on a 5-point Likert scale 1 (strongly disagree) to 5 (strongly agree), and mean scores are calculated. Higher scores represent a greater risk of expulsion.

The *Student Teacher Relationship Scale Short Form (STR-SF)* was used to assess teachers' perceived relationship quality with individual students [56]. This 15-item scale includes two subscales: closeness (8 items) and conflict (7 items). Items are scored on a 5-point Likert scale 1 (definitely does not apply) to 5 (definitely applies). Mean scores are calculated with higher scores indicating more of the quality.

The *Childrens Behavior Questionnaire Very Short Form (CBQ)* was administered to evaluate child temperament [57,58]. This 36-item questionnaire contained three subscales: surgency/extraversion, negative affectivity, and effortful control. The surgency/extraversion subscale includes 12 items about a child's sociability and activity level. Negative affectivity was a 12-item subscale that assesses the frequency of negative emotions such as frustration. Effortful control was a 12-item subscale that focuses on a child's ability to regulate attention and manage impulses. Respondents are asked to read each statement and indicate the child's reaction to that situation. Items are rated on a 7-point Likert scale ranging from 1 (extremely untrue) to 7 (extremely true). If a respondent had not observed the child in the situation, the response was left blank. Mean scores for

each subscale are calculated with higher scores representing poor temperament.

The *Strengths and Difficulties Questionnaire (SDQ)* is a 25-item scale used to measure behavioral and emotional strengths and difficulties in children and young people [59]. This scale is divided into five subscales of five items each: hyperactivity, emotional symptoms, conduct problems, peer problems, and prosocial behavior. Each item is scored on a 3-point Likert scale 0 (not true) to 2 (certainly true). Sum scores are calculated for each of the five scales. A composite total difficulties score is generated by summing the scores for hyperactivity, emotional symptoms, conduct problems, and peer problems. Higher scores for hyperactivity, emotional symptoms, conduct problems, peer problems, and total difficulties denote worse behavior, whereas higher prosocial scores represent better behavior.

Open-ended questions were included in surveys at each timepoint. The teacher surveys included questions regarding expectations for each child in the MMP, what makes the job of teaching the child more or less enjoyable, changes in the child's behavior or typical behavior at school in general and during stressful situations over the course of the intervention. The teacher self-report surveys included questions related to feedback on having the research team visit their classrooms. Teachers were given the opportunity to comment about additional information they would like to share at the end of each survey.

Parent Report on Child.

The *Adverse Childhood Experiences Questionnaire (ACEs)* is a 10-item measure used to identify traumatic events experienced during childhood, specifically involving abuse, neglect, and household dysfunction [60]. Each item prompts respondents to indicate whether specific events occurred in their child's life, with answers scored as 1 (yes) and 0 (no). A total ACEs score is generated by summing the responses across all items. For this study, only eight items were used; items regarding reportable events were removed. The minimum score is 0 and maximum is 8, with a higher score indicating a greater exposure to adverse childhood experiences.

The parent surveys about their child included *open-ended questions* about what makes parenting them more or less enjoyable, changes in the child's behavior or typical behavior at home in general and during stressful situations that occurred over the course of the intervention. In the middle of programming, parents with children in the intervention group were asked if their child shared anything with them about the program. At the end of classroom programming, parents were asked questions about using the calming corner kit at home. Parents were given the opportunity to comment about additional information they would like to share at the end of each survey.

Teacher and Parent Self-Report.

The *Perceived Stress Scale (PSS)* was used to assess how different situations affect feelings and perceived stress over the past month in both teachers and parents [61]. This scale includes 10 items rated on a 5-point Likert scale ranging from 0 (never) to 4 (very often). Scores range from 0 to 40 with higher scores representing greater perceived stress.

The *Mindfulness in Teaching Scale (MTS)* was used to assess teachers in the context of their teacher activities [62]. This 16-item scale is divided into 2 subscales: 8-item Intrapersonal Teacher Mindfulness and 8-item Interpersonal Teacher Mindfulness. Items are rated using a 5-point Likert scale, from 1 (never true) to 5 (always true). Eight items were reverse coded such that subscales and total mindfulness score calculated sums had higher scores indicating a greater level of mindful teaching.

The *Teacher Social Emotional Learning Beliefs Scale (SEL)* is a 12-item scale that assesses teachers' beliefs about social-emotional learning [63,64]. This measure is divided into three subscales each with four items: comfort with teaching SEL, commitment to learning about SEL, and school culture surrounding SEL. Respondents are asked to read each item and rate their agreement with each item for the past four weeks on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Composite scores for each subscale are generated by summing each item's scores, with scores ranging from 4 to 20.

Post Intervention Interviews and Focus Groups

Between June and August 2024, qualitative data were collected through interviews and focus groups with teachers, parents, and administrators. These interviews and focus groups gathered insights into teachers' and parents' perceptions of the program's effectiveness, challenges encountered, and suggestions for improving the program. In the intervention group, five teachers completed interviews, five parents participated in focus groups or interviews. Four interviews were conducted with administrators. In the control group, there were two interviews with teachers and three with parents.

Program Implementation Measures

Several strategies were used to assess implementation fidelity, acceptability, feasibility, and sustainability. In addition to the qualitative interviews, focus groups, and open-ended survey questions about program components (described above), implementation was documented through (a) implementer-reported fidelity assessment forms, (b) teacher-reported activity logs, (c) attendance and engagement logs, (d) videos, and (e) field notes. Fidelity forms were modified from a previous school-based mindfulness study [65] and included fidelity to curriculum components and core process quality (e.g., the day's planned activities, maintaining engagement, overall quality). Teacher activity logs documented when teachers implemented program activities outside of the designated implementation period (which activities, how often, how much time, and in what contexts). Attendance and engagement logs tracked attendance of children and teachers as well as engagement, disruptiveness, and open-ended notes per session. Finally, field notes were written per session to document the contextual factors (e.g., special considerations for child life events, school disruptions, technology difficulties, etc.).

Data Analysis

Qualitative, quantitative, and mixed methods analyses will be used. Scale and subscale

reliability was assessed using Cronbach's alpha. Quantitative data will be analyzed using descriptive and inferential statistics. Standard descriptive statistics are conducted to understand variable distributions (e.g., socio-demographic characteristics). Inferential parametric and non-parametric statistics (mean comparisons, linear regression, moderation) will be used to answer research questions about program and implementation effects. Content and thematic analysis approaches will be used to analyze qualitative data (interviews, focus groups, and open-ended survey responses). Qualitative and quantitative findings will be integrated, where appropriate.

Ethical Considerations

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the University of Illinois Urbana-Champaign Institutional Review Board.

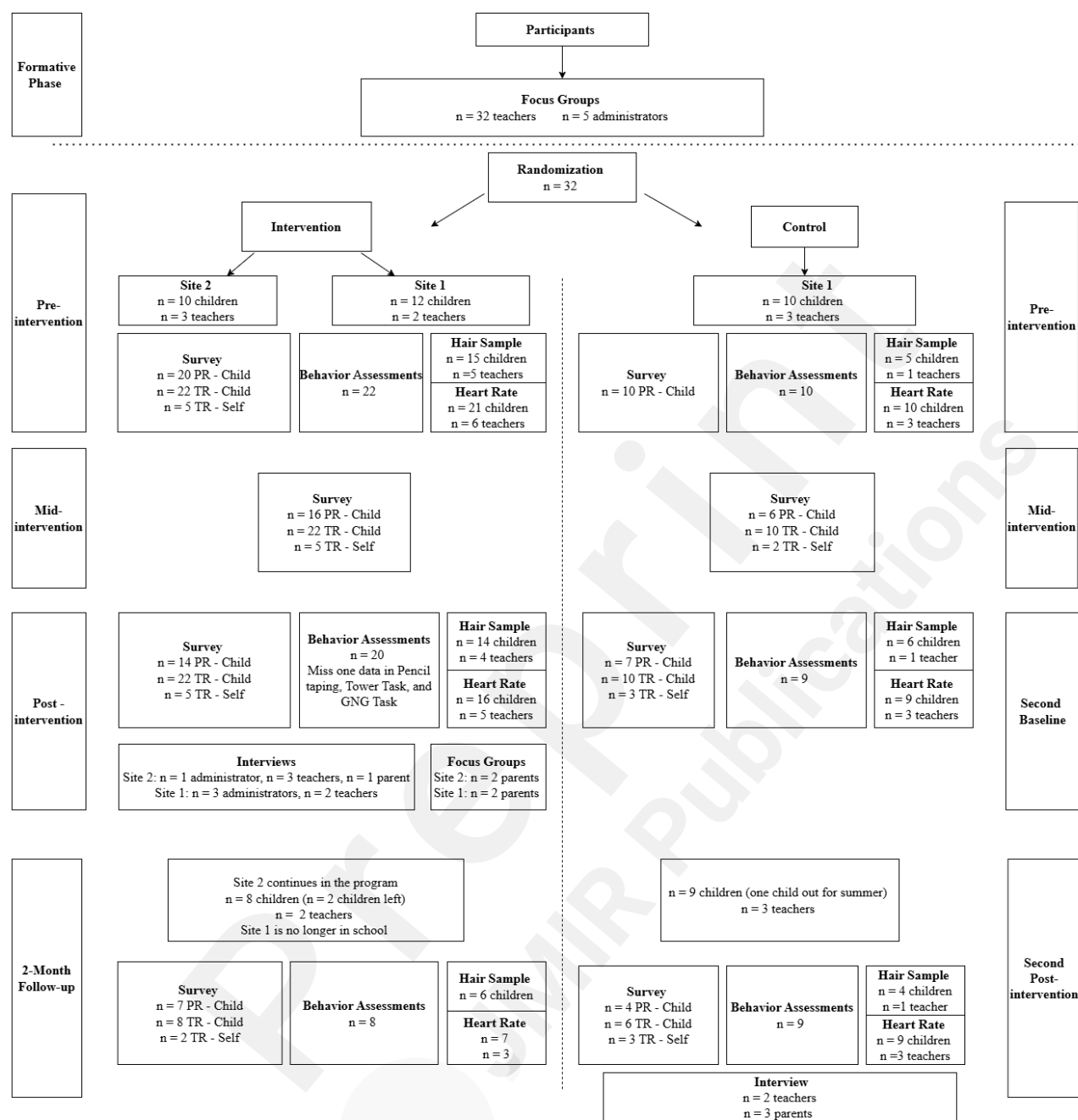
Consent to Participate

Informed consent for children was obtained from legal guardians and teachers provided consent for their own participation.

Results

Demographics and Study Flow of Participants

The intervention and data collection are finished. Currently, data are being processed for analysis. We conducted t-tests for continuous variables and Chi-square tests (Fisher's Exact Test) for categorical variables between the intervention and control groups for children and parents. Results showed only a significant difference in children's age ($t(30)=-2.945$, $P=.006$). There were no other statistical differences in any characteristics. Overall, there was limited attrition across the course of the study. The study flow and sample sizes for each component are illustrated in Figure 2.

Figure 2. Diagram of the Flow of Participants Through Each Stage of the Study

Scale and Subscale Reliabilities

Reliabilities were calculated for each scale and subscale. Alpha values for all scales and

subscales are presented in Table 5. In total, 26 scales and subscales had Cronbach's alpha values at or above .70, two between 0.60 and 0.69, and five at 0.60. A cutoff of .60 is considered acceptable for reliability [66]. For the five subscales below 0.60, we assessed whether removing any items would improve the reliability and found increases to over 0.60 for four (see Table 5).

Table 5. Cronbach Alphas on Survey Measurements

Measures	Alpha	Number of Items	Improved	Items Deleted
Teacher Report on Child				
Preschool Expulsion Risk Measure				
Full Scale	0.96	12		
Classroom Disruption	0.96	3		
Fear of Accountability	0.83	3		
Hopelessness	0.89	3		
Teacher Stress	0.97	3		
Students-Teacher Relationship Scale				
Closeness	0.84	8		
Conflict	0.86	7		
Children Behavior Questionnaire				
Surgency	0.82	12		
Negative Affect	0.57	12	0.61	26R ^a
Effort Control	0.70	12		
Strengths and Difficulties Questionnaire				
Hyperactivity	0.89	5		
Emotional Symptoms	0.68	5		
Conduct Problems	0.70	5		
Peer Problems	0.48	5	0.64	23
Prosocial	0.90	5		
Total Difficulties	0.87	20		
Teacher Report on Self				
Perceived Stress Scale				
Short	0.70	4		
Sum	0.89	10		
Mindfulness in Teaching Scale				
Intrapersonal Teacher Mindfulness	0.59	9	0.71	4R ^a
Interpersonal Teacher Mindfulness	0.60	5		
Teacher Social Emotional Learning Beliefs Scale				
Comfort	0.82	4		
Commitment	0.94	4		
Culture	0.41	4	0.67	12
Parent Report on Child				
Children Behavior Questionnaire				
Surgency	0.77	12		
Negative Affect	0.80	12		
Effort Control	0.75	12		
Strengths and Difficulties Questionnaire				

Measures	Alpha	Number of Items	Improved	Items Deleted
Hyperactivity	0.75	5		
Emotional Symptoms	0.49	5	0.53	16
Conduct Problems	0.70	5		
Peer Problems	0.62	5		
Prosocial	0.85	5		
Total Difficulties	0.80	20		
Parent Report on Self				
Perceived Stress Scale				
Short	0.77	4		
Sum	0.91	10		

^aR means reversed-coded items. Alphas reported for pre-intervention only.

Discussion

Program Outcomes

The study investigates the effect of an MMP intervention on preschool children's social-emotional, behavioral, and cognitive outcomes, including effects on acute and chronic stress. A mixed methods approach was taken, integrating quantitative, qualitative, and physiological data. The study addresses several notable gaps in the literature including: determining the MMP effects on a sociodemographically diverse population of preschoolers, identifying differential responses by program component (e.g., movement alone, movement plus breathing, etc.), and exploring underlying physiological and social-emotional mechanisms of intervention responsiveness. Taking this approach will further enrich our understanding of potential mechanisms and efficacy of mindfulness-based interventions.

Feasibility and Acceptability of the MMP

Unique to this study is the collection of formative qualitative data used to improve the feasibility and acceptability of programming and design of the research protocol. Results from this pilot study will inform the scaling of the MMP intervention across multiple sites and settings. This MMP will be improved through our evaluation of program feasibility, including whether the program was implemented with fidelity or adaptations at each site by the program implementers and teachers.

Qualitative findings related to program implementation, expectations, and outcomes from parents, teachers, and school administrators will guide modifications. We will utilize observed engagement levels among children, teachers, and parents to identify any additional improvements to the MMP. Furthermore, the study will determine feasibility of collecting diverse forms of data in preschool settings, including physiological (heart rate sensor data and hair samples), behavioral, and survey data.

Strengths

Strengths of the study include its focus on the crucial early childhood period for emotional regulation and behavioral intervention, the investigation of physiological and behavioral mechanisms undergirding the effect mindfulness on outcomes, and the exploration of program implementation feasibility and acceptability among diverse early childhood populations. The study utilizes multiple reporters and data sources to triangulate findings and use a whole-person approach. Moreover, it examines short-term and long-term effects of programming on teacher and child outcomes. It captures potential dose effects by administering 16 weeks of programming to the intervention group and 8 weeks of programming to the waitlist control group. Finally, it incorporates a train-the-teacher model of implementation that can be tested with follow-up, even for two months, to inform the need and frequency for boosters and technical assistance.

Limitations

Limitations include the small sample size of 32 children and eight teachers and the relatively short follow-up period of only two months, leaving the long-term effects uncertain. Teacher effects may affect findings. The use of multiple reporters and data sources (e.g., parents, observations, behavioral tasks) helps reduce potential bias.

Conclusions

Results from this study will enrich our understanding of mindfulness-based interventions on

preschool children. Better understanding of mechanisms of change as well as child responsiveness to different MMP components will inform the tailoring of future programs to determine what works best for whom and under which circumstances. These findings will also guide the scaling of this RCT across additional diverse preschool populations.

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Author's Contributions

JKD conceptualized the study and led the investigation. DAE led project and data management and co-first authored this manuscript. JKD, RJ-G, and HL collected data. JKD, DAE, HL, RJ-G, KNW, and CX formally analyzed and verified data and wrote, reviewed, and edited the original and later drafts.

Conflicts of Interest

None declared.

Abbreviations

MMPs: Mindful Movement Practices

SEL: Social-Emotional Learning

RCTs: Randomized Controlled Trials

MM class: mindful movement class

PBIS: positive behavioral intervention supports

RSA: Respiratory sinus arrhythmia

WL: waitlist

HRV: heart rate variability

GNG: Go/No-Go Task

ANS: autonomic nervous system

HPA axis: hypothalamic-pituitary-adrenal axis

HPG axis: hypothalamic-pituitary-gonadal axis

SNS: sympathetic nervous system

PNS: parasympathetic nervous system

DHEA: Dehydroepiandrosterone

ACEs: Adverse Childhood Experiences

Data Availability

The data that support the findings are not publicly available due to privacy or ethical restrictions.

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Supplementary Files

Figures

Overview of data collection timepoints by experimental group.

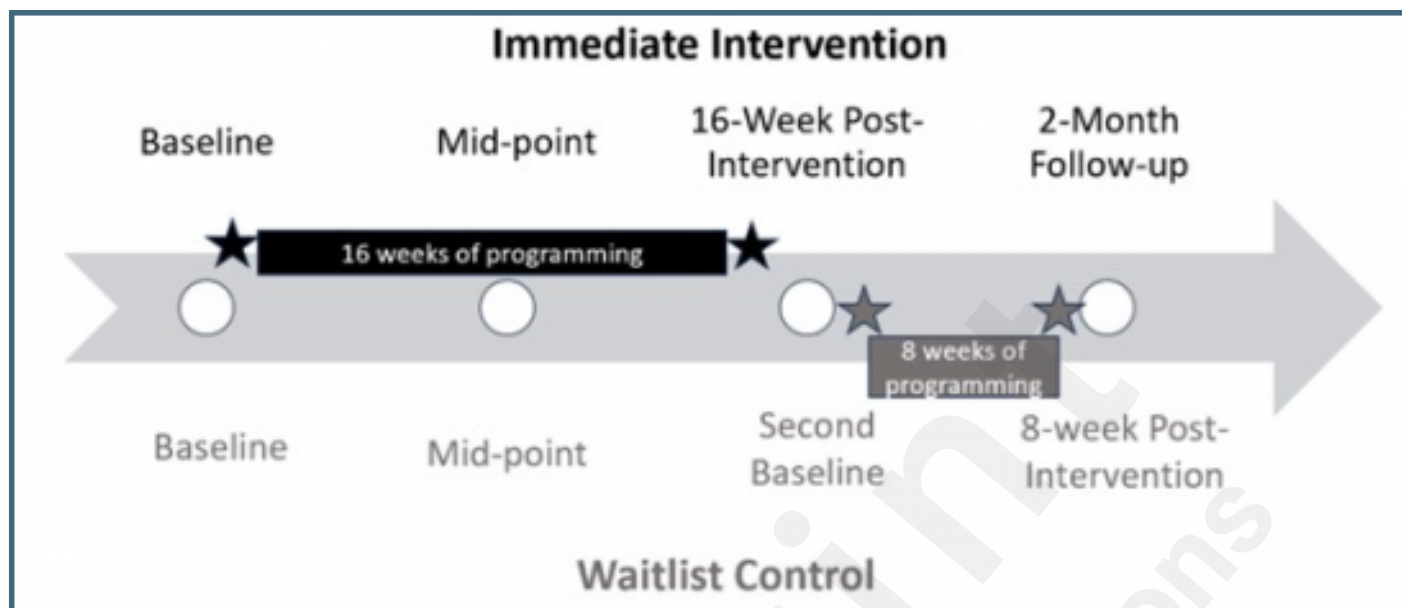
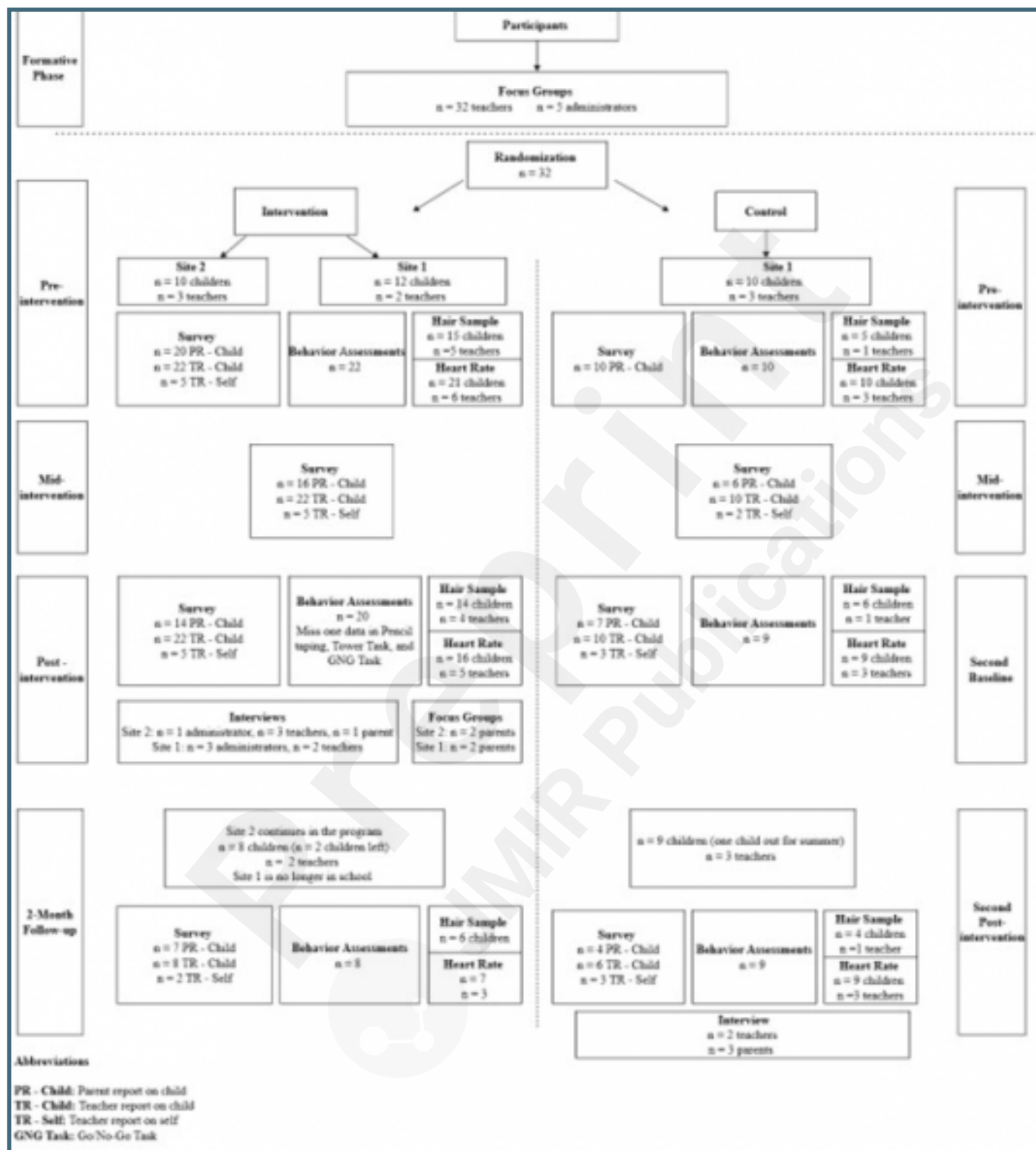


Diagram of the flow of participants through each stage of the study.



Multimedia Appendixes

Granting agency report.

URL: <http://asset.jmir.pub/assets/aea95c37912b15bb1b4de0ca12a4499a.pdf>

