Executive function in early childhood: Harnessing the potential of nature-based practices to elevate and equalize outcomes

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This study examined the effect of nature-based practices on preschoolers' executive function (EF). The Minnesota Executive Function Scale was administered to 147 children within one school district at the beginning and end of the preschool year. Results suggest incorporating nature-based practices into preschool was effective, as children in preschool classrooms where nature-based practices were used had significantly higher levels of EF at the end of the school year than children in programs where nature-based practices were more minimally used. Preschools that used a blended approach (some incorporation of nature-based practices) were significantly more effective than preschools that had lesser incorporation of nature-based practices. Results also point to the effectiveness of a blended approach for supporting EF in lower SES children. This study contributes to the literature regarding effective practices for supporting EF development and adds to the growing body of research surrounding the impact of nature play on child development and school readiness.

KEYWORDS

executive function, working memory, cognitive flexibility, inhibitory control, nature-based early learning, nature play

Introduction

Comprised of social-behavioral, emotional, and cognitive self-regulatory skills and processes, children's social-emotional skills are an essential underpinning of school success (Denham and Burton, 2003). Social-emotional skills also have important benefits beyond the school years, with links to health, employment outcomes, interpersonal relationships, civic engagement, and later educational attainment (Heckman, 2006). Among this broad range of social-emotional skills, executive function (EF) has been

particularly emphasized in the early education field over the last two decades, due to the growing recognition of its importance to young children's cognitive and social-emotional development, school-related behavior, and academic success (Ackerman and Friedman-Krauss, 2017).

Executive function is responsible for coordinating goal-directed behavior (McCabe et al., 2010; Zelazo et al., 2017) and has been described as the brain's air traffic control system (Center on the Developing Child, 2011). EF is one dimension of the broader construct of self-regulation, which also includes emotion regulation, effortful control, and executive attention (Vernon-Feagans et al., 2016). EF helps children do things such as stay focused, see things from new perspectives, resist impulses and temptations, flexibly adjust to changing demands or circumstances, and delay gratification (Blair and Ursache, 2011). EF is related to, but distinct from, intelligence, as it has less to do with possessing knowledge, but instead is about putting that knowledge into practice and being able to reason (Zelazo et al., 2017).

Executive function has been studied from different perspectives and conceptualized in different ways. Neuropsychologists, through studying frontal lobe functioning, generally characterize EF as a specific set of attention-regulation skills that include inhibitory control (impulse control), cognitive flexibility (attention switching), and working memory (mentally "holding" and using information) (McCabe et al., 2010; Blair and Ursache, 2011). These skills are highly integrated and work together for optimal functioning. In young children, it is suggested that EF may be best thought of as a single overall construct, rather than separate cognitive skills and processes (Wiebe et al., 2008).

Through studying the working memory system, other researchers, in particular from an experimental psychology perspective, have conceptualized this executive control mechanism as working memory capacity (Baddeley, 1986). The concept of working memory has become important to many cognitive psychology theories regarding the control of thought and action (McCabe et al., 2010). Researchers generally, but not uniformly, describe the working memory system as part of a larger memory architecture system where information is perceived, attended to, and retrieved (Baddeley, 1986). A central executive or common attentional control mechanism is responsible for controlled processing in working memory that allows for directing attention, maintaining task goals, decision-making, and memory retrieval (Cowan, 2005). Despite different conceptualizations, theorists tend to acknowledge a relationship between executive function and working memory capacity, with research suggesting they may share a common underlying executive attention component that predicts higher-level cognition (McCabe et al., 2010).

With the robust positive relationship between children's EF and their early literacy and mathematical skills (Shaul and Schwartz, 2014), there is strong interest among early

childhood policymakers and other stakeholders in supporting young children's EF development through instruction or programmatic efforts (Jones et al., 2016). While low EF has severe consequences for children's academic achievement, even mild EF difficulties influence a child's ability to meet their full potential (Carlson, 2018a). Additionally, with the significant relationship between EF and childhood socioeconomic status (SES), there is strong motivation to support EF development in children from lower-income families (Lawson et al., 2018). As stress, health, parenting behavior, cognitive stimulation, and language exposure also vary with SES, and in light of EF being influenced by interactions among numerous environmental factors, there is further motivation to support EF in children of lower SES. The "negative cascade of academic, behavioral, and peer failures that is often initiated when children enter school with under-developed social and self-regulation skills," alongside growing numbers of children in low-income families, makes accessible and effective EF skill support during early childhood even more significant (Bierman et al., 2016, p. 11).

While growth in EF follows an age-related trajectory of development and is highly dependent on the rapid development of the prefrontal cortex during the ages of 3–6 (Center on the Developing Child, 2011), research suggests environmental factors and exposure to early learning programs and other specific interventions can influence EF skills (Ackerman and Friedman-Krauss, 2017). Interactions with parents and caregivers have been shown to influence EF, with caregiver sensitivity (Landry et al., 2000), language ("management language" v. direct commands) (Bindman et al., 2013), autonomy support (Matte-Gagne and Bernier, 2011), and intentional scaffolding of children's problem-solving (Bibok et al., 2009) having a positive influence on children's EF.

These influential factors align with research regarding teachers' contributions to supporting EF in early childhood. Classroom climate (the absence of a negative climate) is influential, as is children's positive engagement in interactions with their teachers and classroom activities (Williford et al., 2013). Teacher behaviors, such as using open-ended questions, providing explanations of the significance of activities, modeling engagement in learning activities, and expressing appreciation for children's efforts to learn and behave, are also related to EF development (Ackerman and Friedman-Krauss, 2017). Additionally, research suggests an inverse association between structured activities and EF, with more time in less-structured activities related to a higher level of EF in young children (Barker et al., 2014). Diamond and Lee (2011) suggest addressing emotional, social, and physical development alongside EF skills through holistic approaches is more effective than interventions solely focused on EF. For example, the Montessori approach (a child-centered educational approach that emphasizes self-directed activity, hands-on learning, and collaborative play) has been associated with children's EF skills (Dias and Seabra, 2015).

Longer-term curricular programs aimed to support EF and socio-emotional skills more broadly also may be effective. One specific curriculum, "Tools of the Mind," is effective in improving preschoolers' and kindergartners' EF through strategies such as formulating play and learning plans that help children self-monitor and evaluate their performance and encourage reflection on how they can modify these plans (Diamond et al., 2007). Other activities specifically designed to increase EF have also been shown effective, such as computer games that focus on children's working memory (Diamond and Lee, 2011), games that involve paying attention to changing rules (Tominey and McClelland, 2011), and card-switching games that involve reflection training on the rules of the game (Center on the Developing Child, 2011). A play-based intervention for preschoolers where children had to help story characters overcome progressively harder challenges was found to be an accessible and effective group-based intervention for increasing all three EF dimensions (Traverso et al., 2015). However, it is important to note that short-term, specific training effects do not appear to generalize to other cognitive skills, but the skills that do improve during the training seem to transfer to other contexts where those same skills are needed (Diamond and Ling, 2016). And without ongoing practice, benefits diminish over time (Diamond and Ling, 2016).

Beyond these early education intervention approaches, research has honed in on the contribution of child-directed pretend play. Symbolic skills in particular are related to EF (White et al., 2017), as is the complexity of pretend play (Slot et al., 2017) and likely the social nature of play (Elias and Berk, 2002; Ivrendi, 2016). Other influential aspects of play appear to be the narrative aspects (story-telling and story-acting), which have been associated with increased inhibitory control (White and Carlson, 2021), as well as the child autonomy and lack of adult structure (Basilio and Rodriquez, 2017). Physically active free play has also been associated with self-regulation performance (Becker et al., 2014) and EF (Carson et al., 2016). Colliver et al. (2022) found unstructured quiet play also predicts self-regulation abilities, speculating that this type of play provides children with opportunities for practicing self-direction.

The characteristics of child autonomy, imagination, social interaction, and physical activity align well with nature play, which is described as freely chosen, unstructured, and open-ended playful interactions with and in nature (Zamzow and Ernst, 2020). In nature play, autonomy in children is intentionally encouraged through a more "hands-off" role for the caregiver; through caregivers' provision of access to outdoor areas with natural loose parts, as well as extended unstructured time for free play, there is an abundance of opportunities for social, active, and imaginative play afforded by nature. Carr et al. (2017) studied the influence of a natural playscape on preschoolers' EF, finding evidence of inhibitory control, cognitive flexibility, and working memory in children's

nature play. They speculate that the opportunities afforded by nature play for problem-solving, risk-taking, as well as self-planning, organizing, and monitoring their play, are what encourage and even enhance EF development (Carr et al., 2017). Zamzow and Ernst (2020) studied the effect of nature play in the context of nature preschool, finding levels of EF growth that exceeded what would be expected in typically developing children, but no significant differences in the EF levels between those attending nature preschool and those attending high-quality non-nature preschool. Their findings align with Weiland and Yoshikawa (2013), where participation in a publicly funded prekindergarten program demonstrated positive effects on children's EF. Thus, while nature play may not detract from children's EF development, additional research is needed to better understand if nature play has an additive effect beyond the contribution of preschool participation to EF development.

Beyond nature play, the association between spending shorter amounts of time in nature and cognitive functioning has also been studied. Schutte et al. (2015) found a 20-min walk in a natural environment promoted children's attentional control, whereas walking along urban streets did not. In a study by Torquati et al. (2017), neural responses indicated children needed greater attentional resources while indoors to complete tasks that required attentional and inhibitory control than when completing the cognitive tasks in nature (Torquati et al., 2017). Their findings are consistent with prior findings suggesting cognitive task performance is better after experiencing a natural setting, relative to an indoor or an urban setting (Faber Taylor and Kuo, 2009; Aspinall et al., 2013).

This small, but growing body of evidence supports the claim that even shorter-term exposure to natural environments can be restorative for cognitive functioning (Torquati et al., 2017), which is consistent with Kaplan's (1995) attention restoration theory. Attentional resources are the basis of EF and self-regulation and are fundamental for academic performance (Mason et al., 2021). Because one's attentional resources are limited and can be depleted (Kaplan, 1995), finding ways to restore them in easy and/or low-cost ways is significant. A recent review of 14 studies of children of education levels varying from elementary to university indicated cognitive benefits emerge in terms of directed attention restoration from mental fatigue due to short-term contact with nature (Mason et al., 2021). However, with the benefits of short-term EF interventions known to diminish over time (Diamond and Ling, 2016), further research is needed to better understand the potential of sustained experiences in and with nature to elevate younger children's EF, given the critical window of early childhood in terms of EF development. Further research also would be helpful in light of the emphasis on school readiness in the landscape of early learning and accompanying concerns regarding unstructured play, and specifically nature play, potentially detracting from children's readiness for school (Sobel, 2022).

Purpose

This study sought to assess the effect of nature-based practices on preschoolers' EF by comparing three preschool program types that differed primarily in terms of the degree to which nature-based practices were incorporated (Less Nature v. Blended v. Nature; see section Design for a description of these). The overarching aim was to contribute knowledge regarding effective practices for supporting EF and add to the growing body of research surrounding the impact of nature play on child development and school readiness. In light of the relationship between EF and SES documented in the literature, the potential for nature-based practices in preschool to reduce the relationship between SES and EF (the potential to "equalize" EF outcomes for higher and lower SES children) was also explored. The study was guided by the following research questions:

1. Do posttest EF levels differ by preschool type (Less Nature vs. Blended vs. Nature), when accounting for age, gender, and pretest level? (Main Effect of Preschool Type).
2. Do posttest EF levels differ by SES (high vs. low), when accounting for age, gender, and pretest level? (Main Effect of SES).
3. Do posttest EF levels differ by duration of participation (full-time vs. less than full-time), when accounting for age, gender, and pretest level? (Main Effect of Duration of Participation).
4. Do the differences in posttest EF levels among the three preschool types vary as a function of SES and/or as a function of duration of participation? (Interaction Effects).
5. If effectiveness varies by SES, which preschool type supports the highest posttest EF levels for lower SES preschoolers? For the preschool type that is most effective for lower SES participants, are posttest EF levels similar for lower and higher SES participants? (Simple main effects).

Materials and methods

Participants

There were 147 children, ages 3–5 years old, who participated in the study. Of the total 147 participants, 55% were female. While there was some SES variation across the study participants as a whole, as well as within-program SES variation for some programs, the majority of study participants were lower SES, using federal/state early learning eligibility guidelines for free or reduced tuition as a proxy indicator of SES (see Berzofsky et al., 2014, regarding use of income as a single proxy indicator of SES). Study participants were enrolled in public preschool within one school district in a metropolitan area

located in the upper Midwestern region of the United States. According to the National Center for Education Statistics (2021), families in this school district have an average median household income of about $55,000. Community members are 89% White, with the remaining percentages relatively evenly distributed across Black, Hispanic or Latinx, Asian, American Indian or Alaskan Native. The school district has 14 preschool programs, located across seven elementary school locations. The district's public preschool integrates federal Head Start programming with state-level school readiness, voluntary prekindergarten, and special education programming, and thus within the 14 programs, some children attend at no cost to families through state or federal funding, and others are attending through income-based tuition. All preschoolers were invited to participate in the study, except for children who spent the majority of their day receiving special education services apart from the regular preschool classroom. See Table 1 for a summary of programs and participants, including the number of participants, and participant demographics.

Design

A non-equivalent pretest-posttest quasi-experimental design was used in this study, as geographic boundaries and parent choice determined which specific preschool program children attended, and random assignment was not possible. The dependent variable was the posttest level of EF, as measured by the Minnesota Executive Function Scale, and the independent variables were preschool type, SES, and duration of participation.

Regarding the independent variable preschool type, preschool programs within this school district varied in the degree to which nature-based practices were used, yet were not labeled or categorized by the school district in this way. Consequently, for the study at hand, programs were assigned to one of three groups (types) differing by their incorporation of nature-based practices used relative to each other. Assignment of programs to these three groups was accomplished by first asking teachers to complete the Preschool "Nature-ness" Categorization Rubric, which is detailed in the Construct and Measures section below (see Table 2; based on Ernst et al., 2021). The rubric has 13 items covering curriculum and instructional practices, nature-related curriculum and instruction practices, teacher roles, and indoor and outdoor environments. For each item, teachers select which of the three responses (cells in the row) best describes their class/instruction. The responses for each item are scored on a three-point scale. Responses in the column on the right were scored one point and reflected less incorporation of nature-based practices. Responses in the middle column were scored two points, and responses in the left column were scored three points, reflecting higher/greater incorporation of nature-based practices. The responses across

TABLE 1 Summary of preschool and study participant data.

Type[a]	Program	Program's degree of "nature-ness"[b]	Program duration[c]	# of study participants	Study participants' average age (mos.)[d]	% of study participants female	% of study participants' lower SES[e]
Less nature	A	19	Full-time (all day, 5 days)	10	54	40	100
	B	24	Full-time (all day, 5 days)	11	55	55	100
	C	25	Full-time (all day, 5 days)	6	53	67	100
	Subtotal	–	–	27	54	52	100
Blended	D	26	Part-time (half day, 4 days)	17	52	65	76
	E	28	Part-time (half day, 4 days)	16	55	65	30
	F	29	Part-time (half day, 4 days)	11	52	65	46
	G	29	Full-time (all day, 5 days)	17	55	59	59
	H	29	Full-time (all day, 5 days)	9	54	56	100
	I	29	Part-time (all day, 3 days)	8	55	75	100
	Subtotal	–	–	78	54	62	64
Nature	J	32	Part-time (half day, 4 days)	5	50	40	100
	K	32	Full-time (all day, 5 days)	9	53	33	100
	L	32	Part-time (all day, 3 days)	11	56	63	100
	M	32	Part-time (half day, 4 days)	7	50	43	100
	N	34	Part-time (half day, 4 days)	10	50	50	60
	Subtotal	–	–	42	51	48	90
Total				147	53	56	78

[a]Less Nature category of preschools indicates less integration of nature-based approaches and lower "nature-ness" scores relative to the other programs; Blended indicates more integration of nature-based approaches and middle-level scores relative to the other programs; Nature indicates the most integration of nature-based approaches and higher scores relative to the other programs.

[b]Score on nature-ness rubric, ranging from 13 to 39, with higher scores indicating higher levels/more nature-based settings, practices, etc.

[c]Full-time is considered all day, 5 days per week; part-time is anything less than full-time.

[d]Age in months at time of the pretest.

[e]Lower SES are participants who are income-eligible for free or reduced preschool tuition based on state and federal guidelines that are dependent on household size and income and based on U.S. poverty guidelines.

the 13 items are scored and totaled. Higher total points indicate greater incorporation of nature-based practices, with the highest score on this rubric being 39 and the lowest being 13.

For the study at hand, the participating preschool programs had nature-ness scores ranging from 19 to 34, with nine different levels (rubric scores) of nature-ness. Patterning after the grouping and terminology from Ernst et al. (2021), these nine scores were ranked low to high, with the lower three scores becoming the category grouping *Less Nature* (an approach characterized by less incorporation of nature-based practices relative to the other programs in the study), the middle three scores becoming the category grouping *Blended* (reflecting more incorporation of nature-based practices than the Less Nature

programs), and the three highest scores becoming the category grouping *Nature* (reflecting the most incorporation of nature-based practices relative to the other programs); see Table 1. This grouping was also guided from a statistical perspective, balancing the overall participant sample size with the number of levels of the independent variable (using three category groupings rather than nine nature-ness scores), in light of the additional number of covariates that would be used in the statistical model. This grouping was checked by the district's early education coordinator, who reviewed teachers' rubric responses, toward ensuring that responses to items on the rubric, as well as the overall rubric scores, were reflective of the program's incorporation of nature-based practices and that

TABLE 2 Preschool "nature-ness" categorization rubric.

	Nature	Blended	Less nature (traditional)
1.	Instructional focus is on both environmental outcomes (nature connection, respect for nature) and Kindergarten preparation (developing curiosity, love of learning, problem-solving, independence, as well as other social-emotional outcomes)	Instructional focus is on both environmental outcomes (nature connection, respect for nature) and Kindergarten preparation (early literacy and math, positive behaviors, and other social-emotional outcomes)	Instructional focus is on Kindergarten preparation, including developing early literacy and math skills and fostering positive in-classroom behaviors, as well as other social-emotional outcomes
2.	Social and emotional learning (as well as other desired outcomes) accomplished primarily through nature play and/or playful, guided outdoor learning, as well as teacher-guided negotiations.	Social and emotional learning (as well as other desired outcomes) accomplished through a combination of developmentally appropriate direct instruction, curriculum materials, indoor play, outdoor play, and outdoor play in nature	Social and emotional learning (as well as other desired outcomes) accomplished through developmentally appropriate direct instruction and curriculum materials, as well as through play (primarily indoors)
3.	More of the day is child-directed than teacher-directed	Relatively equal use of teacher-directed activities and child-directed activity	More of the day is teacher-directed than child-directed
4.	Classroom management toward positive behaviors emphasizes developing empathy and community	Classroom management toward positive behaviors involves a combination of classroom expectations, classroom rules, and developing empathy and community	Classroom management approach oriented toward classroom expectations and rules
5.	Substantial focus on child-directed nature play	Some child-directed nature play encouraged	A small amount of child-directed nature play encouraged
6.	Some teacher-guided nature learning outdoors (with a greater emphasis on child-directed playful learning when outdoors)	Some teacher-guided learning outdoors	Small amount of teacher-guided learning outdoors
7.	Much impromptu nature learning based on what's found outdoors/in nature (including weather-related)	Some impromptu nature learning based on what's found outdoors/in nature (including weather-related)	Infrequent impromptu nature learning outdoors
8.	During outdoor playtime, teacher primarily observes play toward understanding children's interests and interactions, using this information to guide and enrich future outdoor learning and play.	During outdoor play, teacher does a range of things, from actively guiding play or joining into play, to providing ideas for play, to observing children play toward maintaining safety and appropriate child behavior and interactions	During outdoor play, teacher primarily observes and/or actively guides play, toward maintaining safety and appropriate child behavior and interactions
9.	Time in the indoor classroom is primarily child-driven. The teacher sets up the indoor classroom with open-ended activities for children to choose from	Inside, teachers lead small and/or large group activities along with providing time for child-directed play	Inside, teachers structure, organize, and often lead activities for children. There is an emphasis on teacher-designed activities for children.
10.	Emphasis on respect for nature and others (equal emphasis)	Emphasis on respect for nature and others, with slightly more emphasis on respect for others	Emphasis on respect for others (and respect for nature as secondary)
11.	Teachers allow children to work out conflicts on their own as much as possible.	Teachers balance child and teacher negotiation strategies to resolve conflicts.	Teachers provide guided negotiation when conflicts arise.
12.	Indoor environment includes substantial nature content in wall displays, classroom materials, etc. Classrooms softly lit	Indoor environment has some nature content Classrooms brightly lit	Indoor environment emphasizes other things relevant and of interest to preschoolers Classrooms brightly lit
13.	Outdoor environment used is primarily an unmaintained, natural setting(s); a maintained natural playspace is also available	Variety of outdoor environments used, including unmaintained natural area, maintained naturalized outdoor play space, and outdoor playground	Outdoor playground is primarily used when outdoors, with naturalized outdoor play space and/or a natural environment also available

Rubric was slightly adapted from Ernst et al. (2021) so that all items had three response options as opposed to some items having only two response options, to avoid confusion by teachers due to lack of consistency in response options across items. Rubric in Ernst et al. (2021) builds upon the work of Bailie (2016) and Larimore et al. (2019).

programs within a grouping were more similar in terms of integration of nature-based practices to each other than to programs in the other categories.

The rubric itself (Table 1) can be used to describe how these three groups (Nature, Blended, and Less Nature) differed, with the cells in the column on the right characterizing programs that have less incorporation of nature-based practices, the middle column generally descriptive of Blended programs, and the column on the left characteristic of Nature programs). Generally speaking, programs categorized as Nature have a focus on both environmental outcomes (such as respect for nature) and Kindergarten preparation that emphasizes areas such as developing curiosity, love of learning, problem-solving,

and independence, as well as other social-emotional outcomes. Learning across the social-emotional and cognitive domains in Nature programs is accomplished primarily through nature play and/or playful, loosely guided outdoor learning that emerged from children's play and interests. The location for nature play varies, from nature playscapes in an urban setting to more "wild" natural areas. The majority of the preschool day is child-directed, with the teacher helping set the stage for play, modeling play skills or behaviors, facilitating play planning and reflection, and/or observing play toward understanding children's interests and documenting learning.

The programs categorized as Blended tend to be more focused on Kindergarten readiness and early academics than

Nature programs, yet have more incorporation of unstructured nature play than Less Nature programs. Blended programs have relatively equal use of teacher-directed instruction (small and large group activities) and child-directed play. Both the natural areas (such as a nature playscape or unmaintained natural areas) and schoolyards/playgrounds are frequently used for outdoor play in Blended programs. While nature or environmental outcomes are not emphasized over areas of school readiness, which is characteristic of Nature programs, Blended programs incorporate impromptu nature learning based on what children encounter outdoors, and children's interest in and respect for nature are still supported, just not to the extent that they are emphasized in Nature programs.

Programs categorized as Less Nature tend to be heavily focused on early academics and Kindergarten readiness. More of the day tends to be teacher-directed than child-directed, and more of the child-directed play occurs indoors than outdoors. The elementary school playground is primarily used for outdoor play, with occasional use of a nature playscape or a less-maintained outdoor setting. The teacher's role tends to be one of structuring, organizing, and leading activities for children.

For this study, preschool programs were characterized and grouped relative to each other. Thus, while these general descriptions stemming from the rubric can provide a sense of what these categories mean and what the programs within each category were like, it is also helpful to keep in mind that these overarching categories of preschool programs represent a continuum of approaches (or a continuum of incorporation nature-based practices) as opposed to discrete categories, which is often the case when interventions are studied. Therefore, the descriptions stemming from the rubric, alongside the recognition that the category groupings in this study represent a limited range on a continuum of incorporation of nature-based practices, are integral toward an understanding of the independent variable investigated in this study.

Construct and measure

The instrument used for this study was the Minnesota Executive Function Scale (MEFS), developed by researchers Carlson and Zelazo (2014), and available through the company Reflection Sciences. The MEFS is based on an EF measure called the Dimensional Change Card Sort (Zelazo, 2006), which entails sorting cards of different shapes and colors into a matching box based on the rules the examiner presents. While the Dimensional Change Card Sort is administered with physical cards, the MEFS is administered through an application on an electronic tablet.

The MEFS starts each participant on the testing level corresponding with his or her age. Participants are required to sort (by dragging with his/her finger) virtual cards on the screen into boxes according to certain rules. Executive function

is employed when the child must keep current sorting directions in mind, flexibly switch sorting behavior when instructions are changed, and inhibit the reflex of sorting in the same way as previously. One advances to the next level if the current level is passed, and he or she will continue advancing until failure of a full level. If the participant fails his or her starting level, the program will automatically switch to an easier level until the current level of functioning is reached. Each participant's performance is scored automatically.

The MEFS task takes 2–7 min to complete, with an average time of 4 min, and can be used to assess children as young as 24 months old. Given the convergence of EF skills in early childhood, the MEFS produces an EF skills total score, rather than three distinct scores for the domains of cognitive flexibility, working memory, and inhibitory control (Zelazo et al., 2017).

The MEFS yields data that is highly reliable and valid. The testing application directs the measurement through automated levels with an examiner script appearing on the screen, and the application calculates the executive function score for the participant; this helps avoid introducing administrator subjectivity into MEFS scores. Test-retest reliability of the instrument is 0.93. Due to the automated scoring through the testing app, the internal consistency of the data from the present study could not be estimated, nor could the pretest and posttest measures be used to conduct a test-retest estimate of reliability, given the time that passed between the administrations and due to the anticipated impact of preschool participation. Validity has been established in several ways. First, the MEFS is significantly correlated with other commonly used research measures of EF, such as the NIH Toolbox Battery of EF Measures often used for clinical purposes and the Heads-Toes-Knees-Shoulders task), and it is predictive of kindergarten readiness and first-grade math achievement (Carlson and Harrod, 2013; Carlson, 2018b). The MEFS is not correlated with IQ, suggesting it is measuring EF rather than intelligence (Zelazo et al., 2017). It also has established external validity. Participants who experience stress, poverty, or other similar factors, which negatively impact their executive function development, usually score lower in the assessment (e.g., Fuglestad et al., 2015), which continues to support the validity claims of this instrument.

Data collection procedures

This study was carried out following the guidelines for human research of the Institutional Review Board for the Social and Behavioral Sciences at the University of Minnesota. They approved the research protocol, which guided the recruitment, invitation, and consent procedures, as well as the data collection procedures. Teachers were asked to complete a summary sheet regarding the demographic information for each child for whom parental consent had been granted. The following demographic data were collected: children's age in months, gender, and SES

(eligibility for free or reduced tuition). Children's race and ethnicity were not collected, due to the lack of variation and to avoid being able to identify specific participants. Pretesting began in September 2021, and posttesting occurred in May 2022.

After completing the required 2-h online training by the test publisher, the researcher administered the MEFS individually to each participating child using the testing app that had been downloaded onto an electronic tablet. To begin the assessment, the examiner read a script that appeared on the tablet screen. The script provided participants with the rules for the upcoming task. The child was then tasked with a rule check to assess his or her understanding before beginning the assessment. After the checks for understanding, the test examiner was no longer permitted to respond to the participant with feedback. During the testing, participants are prompted (by the examiner, who reads the automatically generated script on the screen) to sort virtual cards on the electronic tablet screen into virtual boxes according to certain rules. Children advance to the next level upon passing the current level and continue advancing until the failure of a full level, which then prompts the conclusion of the test. Participants' performance is scored automatically through the testing app.

General analytic strategy

General linear modeling (3 × 2 × 2 ANCOVA) was conducted to evaluate the main effects of preschool type, SES, and duration of participation on posttest EF levels. The three-way and two-way interaction effects were also evaluated. In the model, preschool type (Nature vs. Blended vs. Less Nature), SES (higher vs. lower), and duration of participation (full-time vs. less than full-time) served as the independent variables, and the dependent variable was the posttest level of EF, as measured by the MEFS. Pretest score, age, and gender were covariates in the model. Given the three levels of preschool types, follow-up analyses were conducted to evaluate pairwise differences among the preschool types, averaging across SES, using the Bonferroni adjustment procedures to control the family-wise Type I error rate. Planned simple main effects analyses were conducted to further explore the results of the significance testing of the interaction effect between preschool type and SES.

Results

The means and standard deviations for posttest EF levels as a function of the three factors (preschool type, SES, and duration) are presented in Table 3. When controlling for pretest, age, and gender, there was a significant main effect for preschool type, $F(2, 133) = 2.91$, $p = 0.05$, partial $\eta^2 = 0.04$, but not for SES, $F(1, 133) = 0.15$, $p = 0.70$, partial $\eta^2 < 0.01$, or duration, $F(1, 133) = 0.74$, $p = 0.40$, partial $\eta^2 < 0.01$. Using the Bonferroni

TABLE 3 Unadjusted means and standard deviations for EF posttests by preschool type, SES, and duration.

Preschool type	SES	Duration	Mean (SD)
Less nature	Lower	Less than full-time	–
		Full-time	51.22 (16.12)
	Higher	Less than full-time	–
		Full-time	–
Blended	Lower	Less than full-time	60.84 (7.44)
		Full-time	56.63 (7.04)
	Higher	Less than full-time	59.14 (15.07)
		Full-time	62.00 (6.38)
Nature	Lower	Less than full-time	50.73 (17.11)
		Full-time	54.44 (7.98)
	Higher	Less than full-time	49.75 (21.85)
		Full-time	–

adjustment procedure to control for the Type I error across the pairwise comparisons, follow-up analyses to the main effect for preschool type indicated a significant difference in posttest EF means between the Blended and Less-Nature, $MD = 7.09$, $SE = 2.58$, $p = 0.007$. Participants in Blended preschools had a posttest mean of 58.12 ($SE = 1.46$), and participants in the Less Nature preschools had a posttest mean of 51.03 ($SE = 2.13$). There were no significant differences between the Blended and Nature preschools, $MD = 2.44$, $SE = 2.84$, $p = 0.34$, or between the Nature and Less-Nature preschools, $MD = 4.65$, $SE = 3.21$, $p = 0.15$. These results suggest the effectiveness of Blended preschool programs when the posttest means of higher and lower SES preschoolers and full-time and less than full-time participation are averaged together.

The adjusted means and standard errors for posttest EF levels as a function of preschool type, SES, and duration are reported in Table 4. When controlling for pretest, age, and gender, the three-way interaction between preschool type, SES, and duration was not significant, $F(3, 133) = 0.27$, $p = 0.85$, partial $\eta^2 < 0.01$. When controlling for pretest, age, and gender, the two-way interaction between preschool type and duration was not significant, $F(1, 134) = 0.52$, $p = 0.47$, partial $\eta^2 < 0.01$, nor was the two-way interaction between SES and duration, $F(1, 134) = 0.02$, $p = 0.87$, $\eta^2 < 0.01$.

While the two-way interaction between preschool type and SES also was not significant, $F(1, 134) = 0.50$, $p = 0.48$, partial $\eta^2 < 0.01$, the observed power of this interaction term was low (0.11, computed using alpha = 0.05) and likely insufficient for detecting potential significance. Additionally, the plots of the estimated marginal means of EF posttests visually suggested the potential presence of an interaction effect. Thus, two planned follow-up analyses were conducted to explore the simple main effects, when averaging together full-time and less than full-time duration, with the alpha set at 0.025 to control for Type I error.

The simple main effect of differences in posttest means among preschool types for lower SES preschoolers was

TABLE 4 Adjusted means and standard errors for EF posttests by preschool type, SES, and duration.

Preschool type	SES	Duration	Adj. Mean (SE)[a]	n
Less nature	Lower	Less than full-time	–	–
		Full-time	51.03 (2.13)	27
		Subtotal lower SES (duration combined)	51.03 (2.13)	27
	Higher	Less than full-time	–	–
		Full-time	–	–
		Subtotal higher SES (duration combined)	–	–
		Total less nature (SES and duration combined)	51.03 (2.13)	27
Blended	Lower	Less than full-time	58.79 (2.03)	31
		Full-time	57.39 (2.63)	19
		Subtotal lower SES (duration combined)	58.29 (1.62)	40
	Higher	Less than full-time	57.28 (2.45)	21
		Full-time	58.62 (4.21)	7
		Subtotal higher SES (duration combined)	57.95 (2.44)	28
		Total blended (SES and duration combined)	58.12 (1.46)	78
Nature	Lower	Less than full-time	53.15 (2.19)	26
		Full-time	57.50 (3.72)	12
		Subtotal lower SES (duration combined)	55.32 (2.17)	38
	Higher	Less than full-time	56.38 (5.62)	4
		Full-time	–	
		Subtotal higher SES (duration combined)	56.38 (5.62)	4
		Total nature (SES and duration combined)	55.67 (2.39)	42

[a] Adjusted for pretest, age in months, and gender.

examined to determine which preschool type supported the highest posttest EF level for lower SES preschoolers. Results suggest a significant simple main effect of preschool type for lower SES preschoolers, $F(2, 106) = 3.98$, $p = 0.02$, partial $\eta^2 = 0.07$, which corresponds with a medium effect size. Pairwise follow-up tests using the Bonferroni adjustment to control for Type I error indicated that when controlling for pretest, age, and gender, the lower SES participants in Blended preschools had significantly higher posttest means than their lower SES peers in Less Nature preschools, $MD = 7.26$, $SE = 2.63$, $p = 0.007$. This suggests the effectiveness of Blended preschools for lower SES preschoolers.

The second planned follow-up analysis was a simple main effect test conducted to determine if there were differences in posttest means between lower and higher SES preschoolers in the Blended preschools (as this was the preschool type that produced the highest posttest EF levels for lower SES preschoolers). Results suggest similar posttest means for lower

and higher SES children in Blended preschools when controlling for pretest, age, and gender, as there was not a significant difference in posttest means between lower and higher SES children, $F(1, 73) = 0.01$, $p = 0.96$, partial $\eta^2 < 0.01$. This suggests that in Blended preschools, the lower SES preschoolers were on par with their higher SES peers in terms of end-of-school-year EF levels when controlling for pretest, age, and gender.

Discussion

This study sought to assess the effect of nature-based practices on preschoolers' EF. The overarching aim was to contribute knowledge regarding effective practices for supporting EF and add to the growing body of research surrounding the impact of nature play on child development and school readiness. In light of the relationship between EF and SES documented in the literature, the potential for nature-based practices in preschool to reduce the relationship between SES and EF (the potential to "equalize" EF outcomes for higher and lower SES children) was also explored.

Discussion of findings and implications for research and practice

The results suggest incorporating nature-based practices into preschool was effective. Children in preschool programs that incorporated some nature-based practices (Blended) had significantly higher EF levels at the end of the school year than children in programs where nature-based practices were more minimally used (Less Nature). Preschools that were primarily nature-based (Nature) did not differ significantly from the preschool programs that used some nature-based practices (Blended). These findings are consistent with recent findings in a study focused on young children's resilience (Ernst et al., 2021), where blended preschool programs were more impactful than non-nature programs on self-regulation and attachment, and nature preschool programs did not lead to even stronger outcomes than blended programs for those specific outcomes. Similarly, in the study at hand, some incorporation of nature-based practices appears to be better than none in terms of supporting EF in preschoolers, but even greater incorporation of nature-based practices in preschool did not appear to be more impactful than the blended approach.

The EF literature provides some possible explanations for this impact of nature-based practices and the blended approach in particular. Through the incorporation of unstructured play in nature or naturalized outdoor settings, the influences on EF such as child autonomy (Basilio and Rodriquez, 2017), imagination (White et al., 2017), social interaction (Ivrendi, 2016), and physical activity (Carson et al., 2016), could individually or

collectively account for this impact of nature-based practices on EF. And while these elements could also correspond with unstructured play in a typical schoolyard or even indoors, researchers have speculated that the opportunities afforded by the dynamic aspect of nature for problem-solving, risk-taking, persisting through challenging tasks, and the potentially greater opportunities for physical activity and autonomy are what support and even enhance EF development (Carr et al., 2017). According to Liu et al. (2017, p. 4), playful learning experiences "characterized by joy, meaning, active engagement, iteration, and social interaction can offer multimodal inputs that stimulate interconnected networks involved in learning." Nature play seems particularly conducive to providing children with joyful, active, meaningful, and ongoing opportunities to make connections between familiar and unfamiliar stimuli, which, as described by Liu et al. (2017) guide the brain in making effortful learning easier. Perhaps with the dynamic nature of natural settings and the authentic contexts afforded through them, nature play is favorable to EF development through introducing novel stimuli that children process and link to existing mental frameworks, thereby drawing from and strengthening parts of the brain associated with related cognitive processes (Liu et al., 2017). Research by Barker et al. (2014) surfaced unguided practice (self-directed opportunities to need and use EF), enrichment outings, and some forms of play as the main drivers of the relationship between EF and time in less-structured activities, all of which are characteristic of or aligned with nature-based practices.

In addition, Diamond and Ling (2016) provide useful context for considering why incorporating nature-based practices may be impactful on young children's EF development. In their review of evidence regarding effective EF interventions, they highlight Moreau and Conway's (2014) general principles of complexity, novelty, and diversity, which again resonate with the type of experiences afforded by nature. They conclude their research review by suggesting EF interventions and training programs will be more effective if children's emotional, social, and physical needs are also addressed, as stress, sadness, loneliness, and poor physical health impair EF (Diamond and Ling, 2016). Nature is known to foster social interactions and support the development of social relationships (e.g., Coley et al., 1997; Faber Taylor et al., 1998; Sullivan et al., 2004). Time in nature is also associated with better sleep, as well as other physical and mental health outcomes (Dankiw et al., 2020). With the fundamental interrelatedness of developmental domains and with time in nature fostering overall good emotional, social, and physical health, it is not surprising to see cognitive benefits such as EF as well.

In light of Blended preschools in this study being significantly more effective than the preschool programs with less incorporation of nature-based practices, the growing body of evidence regarding the benefits of short exposures to nature on cognitive task performance (i.e., Aspinall et al., 2013;

Schutte et al., 2015; Torquati et al., 2017) is useful to consider alongside the review by Mason et al. (2021), which provides further evidence of directed attention restoration from mental fatigue due to short-term contact with nature. Consistent with Kaplan's (1995) attention restoration theory, it may be that Blended programs offered the "dose of nature" needed to restore children's depleted attentional resources, while still allowing children to benefit from directed skill practice (e.g., Ramdass and Zimmerman, 2011), and particularly if in combination with less-structured playtime outside of the school day (Barker et al., 2014). Policy research by Pennsylvania State University (Bierman et al., 2016, p. 7) suggests the "key to long-term benefits for all children, including closing the school readiness gap that affects children growing up in poverty, is the combination of a preschool focused on social-emotional skill development *and* cognitive enrichment," or in other words, one that "prepares children effectively for the academic demands of elementary school, and develops and nurtures their social-emotional skills." Perhaps the Blended preschools in this study successfully balanced preschool experiences in a manner that addressed these dual needs, effectively supporting the intertwined nature of academic and social-emotional domains in ways that fostered EF, thereby positioning them to enter school well-equipped to succeed in later school years and beyond.

Further research investigating the effectiveness of a blended approach to incorporating nature-based practices would be useful, particularly in light of the study's limitations, as would research exploring its influential characteristics, given the multifaceted nature of this blended approach. Additionally and importantly, research exploring this emerging and intriguing curvilinear (non-linear) relationship between nature-based approaches and EF would also be very useful. The findings here (in essence, some incorporation of nature-based practices was better than none, but more nature-based practices weren't significantly better than some) are somewhat difficult to interpret, particularly given the restricted range of the nature-based approaches in the preschool programs studied. Yet, these findings are consistent with the resilience study mentioned prior that pointed to the effectiveness of a blended approach (Ernst et al., 2021) and with findings by Zamzow and Ernst (2020) where the EF of children in nature-based preschools was not significantly higher than their peers in non-nature preschools. However, implications for both research and practice need to be considered in a temporal context, in light of Ulset et al.'s (2017) study where a curvilinear relationship between outdoor hours and inattention-hyperactivity symptoms emerged over a 4-year age span, and studies where interventions' beneficial impact on EF showed up later or were larger right after then training and then diminished over time (e.g., Holmes et al., 2009; Blair and Raver, 2014).

As Diamond and Ling (2016, p. 43) summarize, "We have known for roughly 50 years that strategies that produce the

best longer-term outcomes often do not produce the best short-term ones, and conversely training strategies that produce the best immediate gains often do not produce the best longer-term benefits." They also point out that while the transfer of improved EF skills occurs, it typically is narrow, and thus they conclude, "If the goal is lasting benefits to more diverse EF skills, then we probably need to be patient. The training will probably need to continue for longer and we will likely need to wait until longer after the training to see the full benefits" (2016, p. 43). Thus, longitudinal research testing both the durability and transferability of the impact of nature-based practices on EF would allow for greater precision in description and application, gauging effectiveness not only by the highest end-of-intervention EF levels but also by which approach produces the most transferable and durable results. Additionally, it is important to recognize that the presence, direction, and strength of a relationship, as well as the type of relationship (linear or non-linear), likely vary by the outcome at hand. For example, in the resilience study (Ernst et al., 2021), the Blended preschools were most effective for fostering self-regulation and attachment, whereas the Nature preschools were most effective for fostering initiative.

The potential for nature-based early learning to elevate preschoolers' EF has great practical significance, as leveraging this potential through a blended approach becomes within the reach of public early learning programs, for whom fully embracing the nature preschool movement or full incorporation of nature-based practices and settings, is not desired and/or has not been feasible. While more research is needed, the study at hand is encouraging, as it suggests that for relatively little financial investment, meaningful and timely impacts might be gained. Additionally, it is particularly encouraging to have benefits occur within a district that is publicly funded, with participants of lower SES, and programs situated in urban settings. Thus, not only does the blended approach to incorporating nature-based practices appear to be effective, but also quite accessible. Durkin et al. (2021, p. 12) point out that despite working memory, attention, and internal self-control being integral building blocks that underlie long-term academic outcomes, little is known about how to facilitate their development in a typical classroom context, and they are often overlooked in "the rush to implement statewide programs that focus on initial school readiness concrete skills." While privately operated nature preschools typically have the resources, flexibility, and support to emphasize outcomes beyond these typical concrete school readiness skills through means of their choosing, a blended approach within a public preschool program may offer an effective intervention that is closer to a typical classroom context, and thus not only more accessible but also likely more acceptable, and thus ultimately conducive to greater equity in terms of who experiences and ultimately benefits from nature-based practices.

Also of practical significance are these findings in light of what has been described as a play disparity in the U.S. that is widening between children from lower and higher SES and exacerbated by a push for universal pre-kindergarten; trends toward less play-based learning, less recess, and greater teacher-directed instruction appear most evident in schools serving high percentages of low-income children of color who often have limited play opportunities outside of school (Dornfeld, 2019; Strauss, 2020). With the established relationship between play and EF, a play disparity might further worsen the existing relationship between SES and EF, all of which makes an accessible version of nature-based, playful early learning even more important. Relatedly, another finding from this study with great practical significance pertains to the potential equalizing effect of the blended approach. For lower SES children, the blended approach was most effective for supporting EF. The posttest EF levels for the lower SES preschoolers in the Blended preschools were on par with their higher SES Blended program peers. Interpreting this from another angle, lower SES children in the Less Nature preschools had EF levels similar to what would be expected for typically developing children at this age (Reflection Sciences, 2021), whereas lower SES children in the Blended programs had EF levels that were seven points higher than what would be expected. These findings are similar to the findings from a study where relative to traditional preschool programs, the Montessori programs equalized outcomes among subgroups that typically have unequal outcomes (Lillard et al., 2017). While more research confirming these findings is warranted, it appears a blended approach to incorporating nature-based practices might not only help lower SES children not fall further behind, it potentially might help them catch up to their higher SES peers.

In terms of implications for nature preschool programs and the nature preschool movement as a whole, these findings suggest that while the preschoolers in the Nature preschool programs didn't have significantly higher posttest levels than their peers in the Blended and Less Nature programs, they kept up with them and even exceeded developmental norms. Thus, their primarily child-directed, nature play-based approach afforded what might conservatively be labeled as sufficient EF development, while likely affording a constellation of other interrelated and relevant cognitive, social-emotional, physical, and environmental outcomes evidenced in the literature (Dankiw et al., 2020) that can be drawn upon as they enter and proceed through their formal schooling and life more broadly. In other words, the results from this study suggest children can spend a significant amount of their preschool day in unstructured nature play and still be "ready for school," given EF's predictability of early academic success. Yet the findings discussed earlier relating to play disparities and EF disparities, coupled with the known demographics relating to the U.S. nature preschool movement (North American Association for Environmental Education [NAAEE], 2017),

point to another implication that arguably might be the more important of the implications. Without collective work to make nature-based practices in early learning settings accessible to a broader demographic, nature preschool programs run the risk of unintentionally widening outcome gaps relating to young children's learning and development, while possibly even possessing the potential to reduce them. In the context specifically of EF, this concern is underscored, given research suggesting the "protective role EF skills may play in the outcomes of children who might otherwise be expected to 'fail' academically due to stressful environmental factors" (Ackerman and Friedman-Krauss, 2017, p. 8).

Limitations

It is necessary to situate the study's findings in the context of its limitations so that the results are interpreted and implications considered in light of them. As is often the case in educational research, a quasi-experimental design was used for this study, rather than the ideal method of a well-controlled randomized trial for evaluating the effectiveness of a school-based program (Flay et al., 2005), since altering enrollment and operating procedures in the district's preschool program to afford random assignment was not possible, nor was implementing other controls to minimize the effects of possible confounding factors. Thus, while this considerably limits the internal validity of the study, it affords a sense of the intervention's effectiveness when delivered under usual conditions in a regular community setting, and thus findings that can be more easily generalized (Flay et al., 2005). This often is the trade-off between internal and external validity in studies of educational interventions, and one that necessitates acknowledging the limitations of the study's internal validity.

One of these limitations stemming from the quasi-experimental design is the potential for preexisting differences in EF, as well as other influences over the school year, from any number of sources, including out-of-school family nature engagement and residential proximity to nature, parks, and playgrounds. Because of the possible influences on children's EF beyond program participation and in light of the lack of random assignment to the preschool program category groupings, an initial analysis of variance test with the pretest scores was conducted to determine whether the pretest means of the EF scores differed significantly across the three preschool types. Results indicated there were no significant differences across the three preschool groups' EF levels at the beginning of the study, $F(2) = 0.93$, $p = 0.40$. Thus, out-of-preschool influences on EF are less of a concern in terms of interpreting the effects of preschool type. If out-of-preschool factors (caregivers, experiences, settings, etc.) had been influencing the preschool participants' EF in ways that differed across the

three preschool types, there likely would have been significant differences already in pretest EF scores. However, there still may have been unaccounted-for preexisting differences or out-of-preschool factors that influenced EF directly over the school year or interacted with other in- or out-of-preschool factors that influenced EF. Similarly, while preschools differed in their level of nature-ness, programs likely differed in other ways (e.g., teachers' instructional style and style of interacting with children); these possible between- and within-group differences may have influenced EF outcomes directly or even interacted with elements of the nature-based approaches, making it challenging to attribute EF outcomes to any one particular factor. A related limitation stems from this study's "nested" data, where participants were within classes within preschool types. Because the groups were a fixed rather than a random factor and due to an insufficient sample size at the program level (Huta, 2014), multi-level modeling was not used, which introduces the possibility of inaccurate statistical estimates.

Also, the intervention itself was challenging to study. While fidelity of program implementation commonly presents a threat to a study's internal validity in educational research, what was further challenging was that the intervention was a continuum rather than discrete categories. The process used to assign preschools to the three program types was guided by prior studies and reviewed by the district's early education coordinator. And while it made sense conceptually and statistically, it was not perfect, and it was further complicated by the preschools being clustered more in the middle of the scoring range as opposed to more widely dispersed across the nature-based continuum. Pre-existing groupings (for example, if the district had programs that were specifically and intentionally defined by and implemented as nature or non-nature programs) or the use of an alternative process for defining and assigning groupings may have led to different results.

Finally, it is important to note that while the external validity of this study was enhanced in that unlike other studies of nature-base approaches in early childhood (e.g., Cordiano et al., 2019; Ernst et al., 2021), which are commonly conducted with privately operated nature preschools and thus tend to have middle or higher SES participants, this study had a majority of lower SES participants. However, the imbalance of higher and lower SES participants both within and across program groups, alongside how SES was measured, necessitates caution in interpreting the findings that pertain to differences in programs' effectiveness by SES.

Conclusion

EF has been particularly emphasized in the early education field over the last two decades, due to the growing recognition

of its importance to young children's cognitive and social-emotional development, school-related behavior, and academic success (Ackerman and Friedman-Krauss, 2017). This study examined the effect of nature-based practices on the development of preschoolers' EF, with findings indicating that programs that used a blended approach (some incorporation of nature-based practices) were more effective relative to programs that had less incorporation of nature-based practices. Fully nature-based programs were similar to blended programs in terms of supporting EF. Findings also indicate that some incorporation of nature-based practices may be an effective way to support EF in lower SES children. Due to the study's limitations, more research is needed to further explore the use of this blended approach as a way to make nature-based approaches more accessible, thereby harnessing the potential of nature-based early learning to elevate and equalize EF outcomes.

Data availability statement

The dataset for this study is not readily available because this data is regarding young children, and parents were not asked to consent to the inclusion of their children's data in a dataset that may be shared with other researchers. Requests to access the datasets should be directed to the corresponding author at jernst@d.umn.edu.

Ethics statement

The studies involving human participants were reviewed and approved by the University of Minnesota Institutional Review Board. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

JE and DS were the principal investigators and designed and provided oversight for the study. AN was the graduate student research assistant and conducted all of the MEFS assessments. JE was responsible for data analysis and led the manuscript preparation. DS and AN contributed to the manuscript writing and review. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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