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The Role of Timing and Amount of Outdoor Play in Emotional Dysregulation in Preschool Children

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ABSTRACT

Background: Currently, the time children spend playing outdoors is at an all-time low. However, the existing literature suggests that outdoor play may have cognitive and emotional benefits for children.

Methods: The present study carried out a mediation analysis to explore whether amount and timing of outdoor play affects children's emotion regulation and whether working memory mediates these relations among 325 preschool children (M_{age} = 4.19, SD = 0.85) residing in a large Midwestern city in the United States.

Results: Results showed that greater amounts of outdoor play very early (i.e., wake-up to noon) and very late (i.e., 6 PM to bedtime) in the day were related to greater emotional dysregulation. By contrast, greater amount of outdoor play from noon to 6 PM was related to lower emotional dysregulation. Importantly, the effect of amount of outdoor play from noon to 6 PM on emotion regulation was fully mediated by working memory.

Conclusion: The findings of the present study suggest that in early childhood outdoor play that supports children's circadian rhythms may have cognitive and, in turn, emotional benefits.

1 | Introduction

Currently, the time children spend playing outdoors is at an all-time low. This is thought to be due to recent increases in fears about crime and safety (Lambert et al. 2019), participation in scheduled extracurricular activities indoors, screen time use (Schwarzfischer et al. 2020) and proportion of dual-income families (Lee et al. 2021). However, outdoor play, especially among young children, is essential for promoting physical activity, sensorimotor skills and overall healthy physical development (Bento and Dias 2017). Over the last decade, there has been a growing body of research with preschool-aged youth focusing on the contributions of outdoor play to areas of development beyond physical activity and health (Dankiw et al. 2020), such as cognitive functioning (Lundy and Trawick-Smith 2020), social skills (Loukatari et al. 2019) and emotional well-being (Gleave and Cole Hamilton 2012). The present study adds to this research by examining another important and understudied area, the relation between outdoor play and emotion regulation in preschool-aged youth. Emotion regulation encompasses the implicit and/or explicit modification of emotional responses to external pressures to support overall well-being (Onchwari and Weengwe 2011). Therefore, understanding paths to emotion regulation is important because emotion regulation difficulties, a transdiagnostic feature, affect learning and personal relationships and may be present before clinical disorders develop (Chaplin and Cole 2005).

Summary

- Greater research exploring the connections between outdoor play and cognitive outcomes is needed to understand its benefits beyond the physical health advantages.
- Despite the growing emphasis on academic preparedness as the main goal of early education, play should be promoted particularly through outdoor play and age-appropriate games in preschool environments.
- Future research should examine both the immediate and long-term effects of a single session as well as sustained outdoor play on working memory and emotion regulation among preschool-aged children.

1.1 | Outdoor Play and Emotion Regulation

The link between outdoor play and emotion regulation in preschoolers is plausible because outdoor play tends to be physically active. The psychological benefits of regular physical activity, such as better mental health, greater emotional well-being, fewer or less severe symptoms of depression, lower anxiety and fatigue, and overall better sleep quality are now well established (Sadeghi Bahmani et al. 2020). Importantly, the link between outdoor play and physical activity seems particularly strong in preschoolers, with evidence clearly showing that a substantial portion of preschoolers' total physical activity is attributed to engaging in outdoor play (Brussoni et al. 2015).

Outdoor play may also benefit physiological regulation via reducing stress (i.e., disruptions in the typical cortisol diurnal rhythm). In general, activities taking place outdoors may be particularly beneficial for reducing stress levels. In one study, children who participated in regular outdoor schooling in a nearby forest once a week exhibited a significant reduction in cortisol levels on the days when teaching took place outdoors (Dettweiler et al. 2017). Importantly, outdoor, compared to indoor, physical activity may benefit physiological regulation more broadly. For example, Thompson Coon et al. (2011) compared the impact of physical activity in indoor environments and outdoor natural environments on psychological and physical wellbeing among adults in a systematic review. Compared to indoor physical activity, physical activity in outdoor natural environments was associated with improvements in anger, tension, and depression. Taken together, there is a wealth of evidence suggesting a physiological mechanism linking outdoor play to emotion regulation.

1.2 | The Role of Cognitive Functioning

Another mechanism of influence may be cognitive functioning and, particularly, executive functioning, a higher level skill that integrates attention and other cognitive functions such as planning, organizing, sequencing and decision making (Yang et al. 2022). The link between outdoor play and emotion regulation via cognitive functioning is plausible for two reasons. First, outdoor play is typically more varied, adventurous, self-directed and unstructured than indoor play (Mak and Koustova 2023). In turn, variability has cognitive advantages as children learn to regulate their emotions and behaviours through implementing rules across a range of play contexts and then apply the learned rules to new circumstances (Mak and Koustova 2023), whereas adventurousness may result in cognitive gains via taking appropriate risks. Moreover, the typically self-directed nature of outdoor play can support the development of children's social and emotional skills, including empathy, talking about emotions, cooperating with others and engaging in positive interactions (Yang et al. 2022). Finally, outdoor play may be cognitively beneficial because it tends to be unstructured and therefore less behaviourally controlled. A recent study, for example, showed that after engaging in 60 min of unstructured outdoor play, preschool-aged children demonstrated improved attentional control in the classroom compared to when they engaged in 60 min of indoor play (Koepp et al. 2022). According to the authors of the study, this may be because indoor play environments require children to exert more control over their behaviour, which can be taxing on their executive functions. In contrast, outdoor play environments require less regulation of behaviour, therefore promoting better attention engagement following play (Nigg 2017). In the same study, indoor play had either null or negative relations with classroom-based executive functions, suggesting that greater amount of indoor activity is related to more dysregulated behaviour.

Second, as discussed earlier, among young children, the amount of time playing outdoors is a strong predictor of level of physical activity (Hinkley et al. 2008), related to cognitive functioning (Sibley and Etnier 2003). In turn, some higher executive cognitive functions, such as inhibitory control (the ability to resist impulsive behaviour or emotions and suppress additional distractions and surrounding temptations), attention and working memory (the ability to retain, update and manipulate information), are strongly associated with emotion regulation (Wolfe and Bell 2004). In general, emotion and cognition are particularly intertwined in young children. They work closely together to process information and take action (e.g., Cacioppo and Bernston 1999), with some empirical evidence indicating that cognition and emotion are fully integrated by the time children reach school age (Blair 2002).

The evidence for the role of physical activity in cognitive functioning in children is generally very robust. For example, a study found relations between the amount and intensity of physical activity in children and their subsequent academic performance and cognitive skills (Fedewa et al. 2015). In general, exercise can increase blood flow to key areas of the brain that are involved in learning, result in positive changes in the volume of brain structures and improve children's performance in regions responsible for attention, inhibitory control and working memory (Esteban-Cornejo et al. 2017; Ortega et al. 2017). For example, one study found that a 20-min session of moderate-intensity walking on a treadmill led to immediate changes in brain-wave activity in children aged 8 to 10 years old (Drollette et al. 2014). In that study, changes in the amplitude of the P3 brain wave, an indicator of focused attention, were higher in children after exercising. This change in brain activity may explain why the same children performed better on a cognitive control task after exercise, particularly in their ability to concentrate and inhibit impulses. That study therefore shows that physical activity can have an

immediate positive impact on children's cognitive abilities, in turn suggesting that among young children cognitive performance is enhanced after engagement in outdoor (and therefore typically active) play. Taken together, all this evidence suggests that children who engage in outdoor play during the early years both exercise and play, with each activity supporting emotion regulation.

1.3 | The Role of Timing of Outdoor Play

An important factor to consider when examining the role of outdoor play is the time of the day at which the outdoor activity takes place, as supported by literature on child chronotype and the circadian clock. An individual's chronotype indicates their preferred schedule for waking and sleeping, which is associated with distinct characteristics of the circadian clock. In children, chronotype is commonly categorized into three groups: 'morning', 'intermediate' and 'evening' (Jafar et al. 2017). Children who belong to the evening-type group are believed to experience increased misalignment between their biological and social schedules, also known as 'social jetlag' (Taillard et al. 2021). This misalignment may occur as a result of later bedtimes and/or consistent early wake-up times, stress or inconsistencies in household routines, which in turn affect children's sleep schedules (Miller et al. 2016) and subsequently their physiological and emotional regulation.

Therefore, those playing outdoors in the later hours may be evening-type children who are outdoors during a time when the majority of their same-age peers are indoors and getting ready for bed. In turn, children with an evening chronotype, particularly in the early stages of development, are more likely to be emotionally dysregulated (Gruber et al. 2012; Van der Heijden, de Sonneville, and Swaab 2013). Yet there is limited understanding on whether variations in chronotype play a role in the development of emotion regulation in preschool children who have not yet been introduced to the formal education system and fixed school start times. On the other hand, it may well be that families whose young children play outdoors in the later hours have difficulties managing routines and schedules or experience higher levels of chaos and instability, in turn related to emotional dysregulation in children (Shapero and Steinberg 2013).

1.4 | The Present Study

Although past studies have explored the link between outdoor play and school readiness (Becker et al. 2018), socioemotional skills (Tori et al. 2019) and executive functions (Koepp et al. 2022), there is very little research into the link between outdoor play and emotion regulation among young children. What is more, the research that does exist has focused on the general impact of specific interventions with outdoor components (Fleer 2017; McCree, Cutting, and Sherwin 2018) rather than explicitly testing the effects of amount and timing of outdoor play or delineating mechanisms of influence beyond exercise.

The present study thus investigates how time spent playing outdoors affects preschool children's emotion regulation, by addressing two research questions: (1) What is the relation between amount and timing of outdoor play and emotion regulation, and (2) does executive functioning (working memory) mediate this relation? It was expected that greater outdoor activity during daylight hours would be positively associated with emotion regulation, whereas outdoor play after dark (i.e., when it is 'risky' and, in this age group who tends to show a very strong morningness preference, a circadian misalignment; Randler, Faßl, and Kalb 2017) would increase emotional dysregulation. It was also hypothesized that more outdoor play during daylight hours would predict greater emotion regulation via increases in working memory. Establishing a link between amount and timing of outdoor play and emotion regulation via cognitive functioning in this age group could have important practical implications for suggesting high-quality educational opportunities and understanding how to strengthen emotion regulation capabilities in young children.

2 | Methods

2.1 | Participants

The present study involved 325 preschool children ($M_{age} = 4.19$, $SD = 0.85$ at Time 1) residing in a large Midwestern city in the United States. All participants were recruited from the Preschoolers' Adjustment and Intergenerational Risk (PAIR) project (2009–2014). The PAIR project is a federally funded, longitudinal study spanning 5 years, designed to investigate the effects of adversity exposure on child development. The present study used Times 1 and 2, which were 6 months apart. Participants were recruited from the local community through partnerships with Head Start programmes, the Department of Social Services and organizations serving low-income families. On average, the income-to-needs ratio of the sample was 0.67, meaning that the average family in the sample received 67% of the income necessary to meet their poverty threshold.[1] Regarding participants' race/ethnicity, the majority of children were parent-identified as Black or African American (72.6%), followed by Caucasian (10.4%), Multiracial (13.6%), American Indian/Alaska Native (1.3%) or Other (2.2%). Regarding maternal educational attainment, approximately 30% of the mothers graduated from some high school, followed by some college (25.5%), and then trade school or community college (18.2%). Approximately half (49.7%) of the children lived in single-parent families, and the vast majority (82.3%) attended preschool during the daytime. Further information about the analytic sample within the PAIR project is presented in Tables 1 and 2.

2.2 | Procedures

All data collection procedures were granted approval by the Institutional Review Board of the principal investigator's university. Following completion of the informed consent process, parents participating in the project first completed the study using paper and pencil to answer questions, with questions being read aloud if they showed challenges with reading or comprehension. Then, subsequent participants completed the study using Audio Computer Assisted Self Interview (ACASI) software, which presented each question-and-answer option audibly and visually on laptop computers. Upon completion of the study measures

TABLE 1 | Descriptive statistics of categorical study variables.

Variable	Category	*N*	Percent
Gender	Female	161	49.5
	Male	164	50.5
	Total	325	100.0
Race/ethnicity	American Indian or Alaska Native	4	1.3
	Black or African American	230	72.6
	White or Caucasian	33	10.4
	Multiracial	43	13.6
	Other	7	2.2
	Total	317	100.0
Preschool attendance	No	56	17.7
	Yes	261	82.3
	Total	317	100.0
Maternal highest level of education	Some grade school	7	2.2
	Some high school	50	15.7
	High school graduate or GED	98	30.8
	Trade school or community college graduate	58	18.2
	Some college	81	25.5
	Four-year degree college graduate	16	5.0
	Graduate or professional school	8	2.5
	Total	318	100.0
Season	Fall	60	18.5
	Winter	58	17.8
	Spring	113	34.8
	Summer	94	28.9
	Total	325	100.0
Outdoor play from wake-up to noon	0 min	128	40.6
	1–15 min	43	13.7
	16–30 min	66	21.0
	31–60 min	45	14.3
	Over 60 min	33	10.5
	Total	315	100.0
Outdoor play from noon to 6 PM	0 min	65	20.6
	1–15 min	47	14.9
	16–30 min	65	20.6
	31–60 min	82	26.0
	Over 60 min	56	17.8
	Total	315	100.0

(Continues)

TABLE 1 | (Continued)

Variable	Category	*N*	Percent
Outdoor play from 6 PM to bedtime	0 min	139	44.4
	1–15 min	51	16.3
	16–30 min	39	12.5
	31–60 min	58	18.5
	Over 60 min	26	8.3
	Total	313	100.0

TABLE 2 | Descriptive statistics of the continuous study variables.

Variable	*N*	Mean (SD)	Min, max
T1 child age	325	4.19 (0.85)	3, 5
Working memory	241	94.79 (16.20)	45, 137
Negativity/lability (emotional dysregulation)	240	27.76 (6.72)	15, 52
Income-to-needs ratio	317	0.67 (0.62)	0.10, 3.05

and activities, participants received a debriefing session, and gift cards were given to compensate for their participation (Griffith et al. 2020).

2.3 | Measures

1. *Demographics*. Caregivers provided demographic information about their child's age, race/ethnicity, gender (0 = *female*, 1 = *male*) and educational level. An income-to-needs ratio that accounts for the federal poverty level and the number of family members that the total income reported was being used to support was also calculated. Other covariates in the study were whether the child attends preschool (0 = *no*, 1 = *yes*) and season, given its importance for amount and timing of outdoor play among young children.
2. *Outdoor play*. Outdoor play was measured using the Outdoor Time Checklist, which asked parents to record the amount of time their child spends playing outdoors each day (Burdette, Whitaker, and Daniels 2004). The checklist was given to the caregivers to fill out when they visited the lab for data collection. Caregivers were instructed to answer the questions based on what a typical day would be like for the child. The day was divided into three separate time periods—wake-up until noon, noon until 6 PM and 6 PM until bedtime. The amount of time spent playing outdoors during each of these three periods was divided into five response options: 0, 1 to 15, 16 to 30, 31 to 60, and more than 60 min. With each option, responses were meant to be mutually exclusive, thus allowing one to calculate all of the child's outdoor play time in a day.
3. *Emotional dysregulation*. Emotional dysregulation was measured using the Lability/Negativity subscale of the Emotion Regulation Checklist (Shields and Cicchetti 1995), a 24-item measure of self-regulation. This subscale indexes unstable/negative emotional reactions and difficulties with emotion regulation. It includes 15 questions (e.g., 'Is prone to angry outbursts/tantrums easily' and 'Is impulsive [can't control him/herself]'), answered on a 4-point Likert scale (i.e., 1 = *never* to 4 = *almost always*). The lowest possible score for lability/negativity is 15, and the highest is 60. The emotion lability/negativity subscale consists of items that evaluate reactivity, arousal emotional intensity, flexibility, mood lability and expression of negative emotions. Higher scores on this subscale suggest that the child exhibits exaggerated and rapid mood changes and emotional reactions.
4. *Working memory*. Working memory was measured with the Wechsler Preschool and Primary Scale of Intelligence (WPPSI; Wiloughby et al. 2018). The total composite score for the working memory domain (standardized based on the child's age) was used for the present study.

2.4 | Data Analysis

First, an analysis of frequencies and descriptive statistics summarizing the characteristics of the sample and study variables was performed (Tables 1 and 2). Then, a mediation analysis using the PROCESS macro for SPSS was carried out (Hayes 2013; Figure 1). To answer the first research question of whether timing and amount of outdoor play were significantly associated with emotional dysregulation 6 months later, path c' testing the direct effect of outdoor play on emotional dysregulation was first examined. Longitudinal designs can offer a more robust examination of whether increased outdoor play time enhances emotion regulation abilities. Then, to answer the second research question of whether working memory mediated that association, path a (the effect of outdoor play on working memory) and path b (the effect of working memory on emotional dysregulation) were examined.

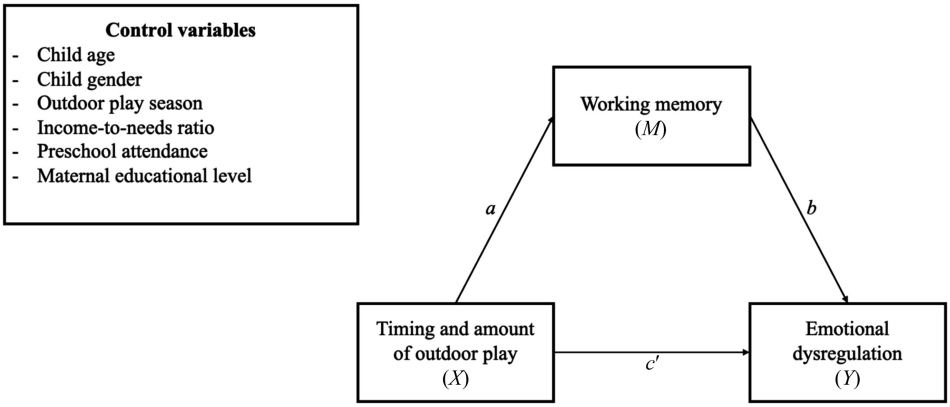

FIGURE 1 | Simple mediation between outdoor play, working memory and emotional dysregulation.

In all regression models, multiple imputation was used to handle missing data (van Ginkel et al. 2020). Although multiple imputation may not be suitable in certain situations involving a high number of missing variables or when data is not missing at random (NMAR), this does not apply to the present study.

3 | Results

The effects of outdoor play and working memory on later emotional dysregulation and the results of the mediation analysis are shown in Table 3. For our sample, children's mean lability/negativity scores were 27.76 (SD = 6.72) and ranged from 15 to 52. Of the 240 children who had information for emotion dysregulation at Time 2, 36 children (15%) deviated from the 1.0 SD cut-off score, signifying significantly increased emotional dysregulation (Shields and Cicchetti 1997). Model 1 estimates the direct effect from amount and timing of outdoor play to emotional dysregulation, adjusting only for the control variables. This model shows that greater amount of outdoor play from wake-up to noon ($b = 0.83$, $t[324] = p < 0.01$) and 6 PM to bedtime ($b = 0.86$, $t[324] = p < 0.01$) had significant and positive relations with emotional dysregulation 6 months later, implying that greater amount of outdoor play very early and very late in the day predicted greater emotional dysregulation. On the other hand, greater amount of outdoor play from noon to 6 PM had a significant and negative relation with emotional dysregulation 6 months later ($b = -0.70$, $t[324] = p < 0.05$).

In Model 2, the path from outdoor play (X) to the mediator, working memory (M), was tested. The paths from outdoor play from wake-up to noon and from 6 PM to bedtime did not have statistically significant associations with working memory, whereas greater amount of outdoor play from noon to 6 PM predicted better working memory ($b = 1.61$, $t[324] = p < 0.05$). Model 3 tested the path from outdoor play to emotional dysregulation, in the presence of working memory. Model 3 first revealed that the mediator (working memory) was significant when controlling for outdoor play at all three time segments ($b = -0.08$, $t[324] = p < 0.01$). Second, controlling for the mediator (working memory), outdoor play from wake-up to noon ($b = 0.85$, $t[324] = p < 0.001$) and from 6 PM to bedtime ($b = 0.88$, $t[324] = p < 0.01$) was still a significant predictor of emotional dysregulation. However, outdoor play from noon to 6 PM was no longer significant when working memory was controlled for. In other words, the effect of amount of outdoor play between noon and 6 PM was significant only when working memory was absent from the model. When working memory was controlled for, this effect became nonsignificant, implying that the effect of amount of outdoor play from noon to 6 PM on emotion regulation was fully mediated by working memory. In addition, both poorer working memory and greater amount of outdoor play in the morning (i.e., wake-up to noon) and evening (6 PM to bedtime) were associated with greater emotional dysregulation but not via a causal link between them.

4 | Discussion

The primary aim of this study was to examine the relations between amount and timing of outdoor play and emotion regulation among preschool children. Our hypotheses that greater amounts of outdoor play during daylight hours would predict lower levels of emotional dysregulation, whereas more time playing outdoors after dark would predict greater emotional dysregulation were partially supported. Our results showed that greater amounts of outdoor play very early (i.e., wake-up to noon) and very late (i.e., 6 PM to bedtime) in the day were related to greater emotional dysregulation. By contrast, greater amounts of outdoor play from noon to 6 PM were related to lower levels of emotional dysregulation.

The finding that amount of outdoor play in the morning (i.e., wake-up to noon) was positively related to emotional dysregulation was unexpected, especially given that amount of outdoor play later in the day (noon to 6 PM) was inversely related to emotional dysregulation. It may well be that more time playing outdoors first thing in the morning is a proxy for lack of routines and structure at home or preschool. It is also quite atypical as over 40% of the children in our sample did not spend any time playing outside before noon. This in turn suggests another possibility, reverse causation. That is, it may be that the more emotionally dysregulated children actively seek out (or are actively encouraged) to play outdoors very early in the morning.

The same effect was found for greater amount of outdoor play very late in the day (6 PM to bedtime). This was however expected as children who play outdoors in the evening may display greater emotional dysregulation due to their evening chronotype. Chronotype is a construct that captures variations among individuals in their inherent circadian rhythms, impacting

TABLE 3 | Outdoor play (X), working memory (M) and emotional dysregulation (Y).

	Model 1			Model 2			Model 3		
	Emotional dysregulation			Working memory			Emotional dysregulation		
	B^a (SE^b)	β^c	t^d	B^a (SE^b)	β^c	t^d	B^a (SE^b)	β^c	t^d
Constant	20.47 (2.59)	—	7.90***	86.29(5.93)	—	14.54***	27.17(3.32)	—	8.19***
Outdoor play from wake-up to noon	0.83 (0.30)	0.17	2.77**	0.21 (0.68)	0.02	0.31	0.85 (0.29)	0.17	2.86***
Outdoor play from noon to 6 PM	−0.70 (0.33)	−0.14	−2.15*	1.61 (0.75)	0.14	2.15*	−0.58 (0.33)	−0.11	−1.78
Outdoor play from 6 PM to bedtime	0.86 (0.30)	0.17	2.86**	0.25 (0.69)	0.02	0.37	0.88 (0.30)	0.18	2.96**
Male	1.68 (0.77)	0.12	2.19*	−2.78 (1.76)	−0.09	−1.58	1.47 (0.76)	0.10	1.93*
Income-to-needs ratio	0.37 (0.66)	0.03	0.57	4.45 (1.50)	0.17	2.97**	0.72 (0.66)	0.06	1.09
Preschool attendance	−3.37 (1.06)	−0.18	−3.17***	−5.12 (2.43)	−0.12	−0.89	−3.77 (1.05)	−0.20	−3.57***
Maternal education	−0.25 (0.31)	−0.05	−0.79	0.05 (0.72)	0.00	0.06	−0.24 (0.31)	−0.05	−0.79
Fall	0.72 (1.26)	0.04	0.57	6.75 (2.89)	0.17	2.33*	1.25 (1.26)	0.07	0.99
Spring	−0.14 (1.13)	−0.01	−0.13	5.14 (2.59)	0.16	1.98*	0.26 (1.12)	0.02	0.23
Summer	−1.28 (1.17)	−0.08	−1.09	4.50 (2.68)	0.13	1.68	−0.93 (1.16)	−0.06	−0.80
Child race: Native American	−2.19 (3.22)	−0.04	−0.68	0.16 (7.37)	0.00	0.02	−2.17 (3.17)	−0.04	−0.69
Child race: White	0.17 (1.26)	0.01	0.13	5.23 (2.99)	0.10	1.82	0.57 (1.25)	0.03	0.46
Child race: Multiracial	2.05 (1.13)	0.10	1.82	−0.62 (2.58)	−0.01	−0.24	2.00 (1.11)	0.10	1.80
Child race: Other	−0.20 (2.43)	−0.00	−0.08	−4.93 (5.56)	−0.05	−0.89	−0.58 (2.40)	−0.01	−0.24
Child age	1.97 (0.48)	0.24	4.14***	0.10 (1.09)	0.01	0.09	1.98 (0.47)	0.24	4.22***
Working memory (M)							−0.08 (0.02)	−0.17	−3.17**
F	3.41***			2.60***			3.91***		
R^2	0.14			0.11			0.17		

[X_1: Outdoor play from wake-up to noon]
Direct effect ($c' = X_1 \rightarrow Y$): $B = 0.84$, 95% confidence interval = [0.26, 1.42]
Indirect effect ($a * b = X_1 \rightarrow M \rightarrow Y$): $B = -0.02$, 95% confidence interval = [−0.13, 0.09]
Total effect ($c = [a * b] + c' = X_1 \rightarrow Y$): $B = 0.83$, 95% confidence interval = [0.24, 1.41]

(Continues)

TABLE 3 | (Continued)

	Model 1			Model 2			Model 3		
	Emotional dysregulation			Working memory			Emotional dysregulation		
	B^a (SE^b)	β^c	t^d	B^a (SE^b)	β^c	t^d	B^a (SE^b)	β^c	t^d
[X_2: Outdoor play from noon to 6 PM]									
Direct effect ($c' = X_2 \rightarrow Y$): $B = -0.58$, 95% confidence interval = [−1.22, 0.06]									
Indirect effect ($a * b = X_2 \rightarrow M \rightarrow Y$): $B = -0.13$, 95% confidence interval = [−0.30, −0.01]									
Total effect ($c = [a * b] + c' = X_2 \rightarrow Y$): $B = -0.70$, 95% confidence interval = [−1.35, −0.06]									
[X_3: Outdoor play from 6 PM to bedtime]									
Direct effect ($c' = X_3 \rightarrow Y$): $B = 0.88$, 95% confidence interval = [0.30; 1.47]									
Indirect effect ($a * b = X_3 \rightarrow M \rightarrow Y$): $B = -0.02$, 95% confidence interval = [−0.12; 0.08]									
Total effect ($c = (a * b) + c' = X_3 \rightarrow Y$): $B = 0.86$, 95% confidence interval = [0.27; 1.46]									

[a]Unstandardized beta coefficient.
[b]Standard error.
[c]Standardized beta coefficient.
[d]t score.
*$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$.

physiological and behavioural functions such as hormone regulation, peak alertness periods and sleep–wake patterns. Circadian rhythms are likely to change across development and may grow into problems with cognition, mood and physical health when misaligned (Carr et al. 2007). From a developmental perspective, young children are more likely to exhibit morningness rather than eveningness (Doi, Ishihara, and Uchiyama 2015), although some individual differences do exist. These differences are influenced by external and internal factors including parental influence, biological aspects, schedules related to school, social activities and parent work patterns. Thus, the preschoolers in our sample engaging in evening outdoor play may be evening-type children who, for various reasons, are playing outdoors when most of their same-age peers are indoors, winding down from their day and getting ready for bed. Evening-type children, especially so early in development, are in turn more likely to be emotionally dysregulated (Gruber et al. 2012; Van der Heijden, de Sonneville, and Swaab 2013). They are also less likely to engage in specific bedtime routines during the 30 min prior to going to bed (Mindell and Williamson 2018). These routines often involve quiet and calm activities, being read to and teeth brushing (Zimmerman 2016). In a study of toddlers, the introduction of a bedtime routine was linked to shorter time taken to fall asleep and increased ease transitioning to sleep (Mindell et al. 2009). Evening-type children were less likely to participate in calm activities during the 30 min prior to bedtime and were more prone to having no established bedtime routine at all. Notably, the children in our sample grow up in relatively poor families and may be at greater risk for disturbed sleep routines and its negative effects. To illustrate, past studies have found children in low-income populations are more likely to sleep fewer hours and have later bedtimes (Buckhalt, El-Sheikh, and Keller 2007). Sleep difficulties have in turn been linked to emotional dysregulation (Berger et al. 2012). Moreover, the negative effects of poor sleep have been found to be potentially worse for children growing up in low-income families (Bagley et al. 2015). This implies that evening outdoor play may lead to presleep arousal for these children as well as few opportunities for calm activities to help the transition to bedtime. In turn, greater presleep arousal has been linked to sleep disruptions (Hoyniak et al. 2021), increasing the occurrence of negative emotions and altering the ways individuals understand, express and modify these emotions (Palmer and Alfano 2017). Nevertheless, it may be that, again, reverse causation is at play. That is, it is possible that in our sample, the more dysregulated preschoolers simply showed increased eveningness.

The second aim of the study was to explore whether working memory mediated the relation between outdoor play and emotional dysregulation. In our sample, outdoor play from wake-up to noon and from 6 PM to bedtime did not have any statistically significant relations with working memory. As such, no conclusions can be drawn about a mediating role of working memory for outdoor play that takes place in the mornings and evenings. These null associations may be due to two reasons. First, it may be that not enough physical activity or time spent outdoors takes place during these time periods. In fact, nearly one half of the sample spent no time engaging in outdoor play from wake-up to noon and from 6 PM to bedtime (40.6% and 44.4%, respectively), whereas approximately one fifth of the sample (20.6%) spent no time playing outdoors from noon to 6 PM, indicating that children tended to play outdoors from noon to 6 PM. Second, as explained, it is possible that greater amount of outdoor play very early and very late in the day approximates a more disadvantaged context for our study population and, thus, no cognitive benefits would be expected.

However, working memory was found to fully mediate the positive relation between amount of outdoor play and emotion regulation when it took place between noon and 6 pm. This finding confirms our hypothesis, although it also adds further nuance. It suggests that in early childhood, outdoor play that supports children's circadian rhythms may have cognitive and, in turn, emotional benefits. Early childhood is commonly viewed as a stage in development when children frequently engage in abundant outdoor play. However,

research has discovered that preschool-aged children spend most of their time engaging in sedentary activities (Eaton, McKeen, and Campbell 2001). Particularly, as a result of urbanization in major cities, as well as increased inequality, the spaces utilized by children have experienced economic, social and spatial changes, frequently leading to unsafe conditions that discourage outdoor physical activity. Such areas are even more prominent in low-income regions. Moreover, many school systems in the United States are decreasing or eliminating designated outdoor play time such as recess, arguing that it detracts from the academic mission of the schools (Pellegrini 2008; Ozkal 2020).

5 | Conclusion

Promoting play in preschool environments, particularly through outdoor play and age-appropriate games, aligns with the enduring belief in the significance of adopting a holistic approach to early education (NAEYC 2022). Furthermore, the evidence connecting increased outdoor play to positive psychosocial and cognitive outcomes can serve as a contrasting perspective to the emerging sentiment among certain educators and policymakers who emphasize academic preparedness as the primary goal of early education, often leading to strategies that restrict opportunities for play (Bassok, Latham, and Rorem 2016). In a broader sense, we anticipate that these findings will provoke wider exploration of the potential role that outdoor play can have in early childhood education.

The majority of the existing research on outdoor play has primarily focused on the physical health advantages. Only relatively recently have researchers started to explore the potential advantages of outdoor play for a wider range of psychosocial and neurocognitive outcomes (e.g., McNeill et al. 2018; Wen et al. 2018; Xiong, Li, and Tao 2017). However, most of these studies have primarily concentrated on examining the effects of structured physical activity interventions. To date, only a single study conducted in the United States has specifically examined the relation between habitual physical activity and executive functions among preschool children (Willoughby, Wylie, and Catellier 2018), and findings contradicted initial expectations, revealing a negative association between the amount of moderate to vigorous physical activity and executive functions, whereas no significant associations were observed with light physical activity. As such, the present study adds to the still limited evidence to support possible relations between outdoor play and children's cognitive and emotional development in typically developing young children.

Despite the contributions of the study, it is not without its limitations. First, although outdoor play and emotion regulation were measured 6 months apart, we do not have Time 2 outdoor play or Time 1 emotion regulation to truly establish a longitudinal link, limiting the types of conclusions that can be drawn. An underlying objective of this research is to investigate whether increasing the duration of outdoor play for an individual child will lead to corresponding improvements in their emotion regulation abilities. For instance, integrating specific outdoor play times into preschool schedules may be helpful for understanding whether activity breaks, characterized by acute changes in outdoor play, lead to immediate short-term enhancements in emotion regulation (Gordon et al. 2013). Second, the analytic sample comes from children from low-income families in a Midwestern city in the United States and may thus not be representative of the population of all young children. For example, the mechanisms for outdoor play, working memory and emotion regulation may work differently for children living in low-income households due to differences in parenting characteristics (Iruka et al. 2018), type and quality of play and neighbourhood areas (McKenzie et al. 2013), and preschool quality (Crosnoe et al. 2016). Lastly, the sample comes from a relatively older cohort, implying that there may be slight changes to the environment of children growing up today. Although the constructs examined in the present study are not significantly influenced by historical context, trends in outdoor play show greater declines more recently due to dramatic advancements of digital media or screen-based activities (McGlynn-Stewart, Maguire, and Mogyorodi 2020; Reed 2024). It will be useful for future research to examine how such trends affect the way children engage in outdoor play today. More generally, future research should examine both the acute (immediate impact of a session of outdoor play) and chronic effects (long-term impact of sustained outdoor play) of outdoor play on working memory and emotion regulation in preschool-aged children.

Author Contributions

Jane J. Lee: writing – review and editing, writing – original draft, funding acquisition, formal analysis. **Eirini Flouri:** conceptualization, writing – review and editing, supervision. **Yo Jackson:** funding acquisition, writing – review and editing.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Research data are not shared.

Endnotes

[1] Income-to-needs ratio of 1.0 (100%) is living at the poverty line. Smaller values represent deeper poverty. Values from 1.0 to 2.0 represent low income, and values 0.5 or below represent deep poverty (Citro and Michael 1995).

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