BMC Psychiatry

RESEARCH Open Access

Association between early childhood outdoor activity and anxiety symptoms in preschoolers

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Abstract

Background Recently, a decreasing trend has been observed in the frequency and duration of outdoor activity among children, which has garnered concern regarding the potential impacts of this decline during mental health in early childhood. Currently, the association between outdoor activity in early childhood and the symptoms of anxiety disorders in preschoolers remains unclear. The purpose of this study was to investigate the association between the frequency and duration of outdoor activity in children aged 0–1 and 1–3 years and anxiety symptoms in preschoolers.

Methods A cross-sectional study was conducted in 2021 using questionnaires, included 69,571 preschoolers residing in Longhua District, Shenzhen. Data on family social demographics, outdoor activity frequency and duration in children aged 0–3 years, and the anxiety symptoms of preschoolers were collected through parent-completed questionnaires. Anxiety symptoms were measured using the Chinese version of the Spence Preschool Anxiety Scale (SPAS), which assesses symptoms across various dimensions. The association between early childhood outdoor activity and anxiety symptoms in preschoolers was analyzed using a binary logistic regression model.

Results Children 0–1 years of age who were outdoors < 1 times/week had a higher risk of screening positive for anxiety symptoms in preschool age compared with children who were outdoors ≥ 7 times/week (OR = 2.55, 95% confidence interval(CI): 2.22–2.94). Children in this age group who were outdoors < 30 min/session had a higher risk of screening positive for anxiety symptoms in preschool age compared with children who were outdoors ≥ 120 min/session (OR = 1.62, 95%CI: 1.38–1.90). Children 1–3 years of age, who were outdoors < 1 time/week had a higher risk of screening positive for anxiety symptoms in preschool age compared with children who were outdoors ≥ 7 times/week, (OR = 3.10, 95%CI: 2.72–3.54). Children in this age group who were outdoors for < 30 min/session had a higher risk of screening positive for anxiety symptoms in preschool age compared with children who were outdoors time ≥ 120 min/ session (OR = 2.07, 95%CI: 1.73–2.48).

Conclusion Lower frequency and shorter duration of outdoor activity during infancy (0–1 and 1–3 years) had higher odds of screening positive for anxiety symptoms in preschoolers. A frequency of ≥ 7 outdoor activity per week and a duration of ≥ 120 min/session during infancy were associated with lower levels of anxiety symptoms in preschoolers.

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These findings provide actionable insights for parents and caregivers, highlighting the importance of promoting outdoor activity in early childhood care and parenting practices. Future studies should further explore the causal relationship between outdoor activity and the prevention of anxiety.

Keywords Outdoor activity frequency, Outdoor activity duration, Preschoolers, Anxiety symptoms, Early childhood

Introduction

While anxiety in older children is well-studied, research on anxiety in preschoolers remains limited [1]. Studies have demonstrated that the age of onset of anxiety symptoms is approximately 4–12 years old [2–4]. Anxiety symptoms is one of the most common emotional problems in children and can adversely affect their learning and daily life [5]. Anxiety symptoms in preschoolers tended to increase gradually with age and tends to persist into adolescence and adults [6–8]. A longitudinal study in Canada showed that 14.7% of preschoolers maintained consistently elevated anxiety symptoms between the ages of 1.5 and 5.0 [9]. A US study reported a positive screening rate of approximately 10% for anxiety disorder symptoms in preschoolers [10]. The positive screening rate for anxiety symptoms is approximately 9% among Chinese preschoolers [1]. Globally, anxiety-related productivity losses are estimated at approximately $1 trillion per year [11]. Researchers suggest that preschool may be the optimal developmental window for anxiety prevention or early intervention [12, 13].

Recently, there has been a global decline in the frequency and duration of outdoor activity among children. This trend can be attributed to several factors, including increasing urbanization, safety concerns, and the rise of digital media. Children today spend more time indoors engaged with screens and less time exploring and playing outdoors [14–16]. The decrease in outdoor activity has garnered concern regarding its potential impact on children's mental health. For example, children's participation in outdoor activity in the US decreased by 37% between 1997 and 2003 [17]. One survey showed that children aged 3–12 spend less time outdoors than their parents; 56% of mothers reported spending more than 3 h/day outdoors, while only 22% of their children spent a similar amount of time outdoors [18]. Another survey found that the median time spent outdoors by children under 3 years of age was 30–44 min/day in winter months and 75–89 min/day in non-winter months [14].

Our hypothesis is that early childhood outdoor activity, particularly those involving exposure to nature and physical activity, would be associated with anxiety symptoms in preschoolers. Research has shown that outdoor environments have a significant protective effect on children's mental health, potentially alleviating anxiety symptoms through mechanisms such as promoting a sense of well-being, reducing stress, and encouraging social interaction. Conversely, reduced outdoor activity adversely affects their overall development [19, 20]. Outdoor activity can enhance psychological wellbeing, including positive emotions and subjective life satisfaction [21, 22]. An experimental study found that swimming pool activity revealed to be efficacious to train psychomotor skills and increaseadaptive behaviors in children with Autism Spectrum Disorders (ASD) [23]. Children who raised in an environment where both cognitive and motor skills are enhanced can have better chances of increasing Food literacy (FL) and success at school [24]. A study of children aged 4–15 years found that time spent outdoors and the frequency of outdoor activity were associated with social anxiety [20]. A meta-analysis of five small trials found that time spent outdoors was associated with anxiety symptoms in adults [25].

There is limited research on the relationship between outdoor activity and anxiety. There are two problems with the existing studies. First, most research subjects were adolescents and adults, leading to a lack of data on the relationship between early childhood outdoor activity and anxiety symptoms in preschoolers. Second, the sample sizes of existing studies were small. Our hypothesis was that early childhood outdoor activity would be associated with anxiety symptoms in preschoolers. We aimed to demonstrate that lower frequency and shorter duration of outdoor activity during infancy are associated with a higher risk of anxiety symptoms in preschoolers, while giving recommendations on frequency, duration of outdoor activity.

Methods

Study population

Longhua District was chosen for this study due to its status as a rapidly developing urban area in Shenzhen, China, which allowed for a diverse and representative sample. The data for this study were derived from the 2021 survey of the Longhua Children'sStudy (LCS). The LCS is a medical study conducted in Longhua District, Shenzhen, China, that aims to assess the impact of caregiving environments on the early psychological and behavioral development of preschoolers. From September to December 2021, the research team collaborated with all kindergartens in Longhua District, Shenzhen. Research team members conducted child psychological assessments among parents of preschoolers from 250 kindergartens in Longhua District, Shenzhen. Parents of preschoolers with a diagnosis of anxiety disorder or a diagnosis of a serious mental disorder (such

as schizophrenia, bipolar disorder, or severe depression) were excluded from the survey. After obtaining informed consent from parents, a questionnaire survey was conducted. The questionnaire collected information on family demographic characteristics, outdoor activity frequency and duration for children aged 0–3 years, and anxiety symptoms in preschoolers(measured using the Spence Preschool Anxiety Scale). A total of 75,557 questionnaires were distributed and 71,069 questionnaires were collected, yielding a response rate of 94.06%. After excluding 1,498 questionnaires with incomplete information, the final sample size was 69,571. This study was approved by the Ethics Committee of the School of Public Health, Sun Yat-sen University (Ethics Approval No: 2021 – 116).

Measurement of frequency and time of outdoor activity (major exposure variables)

"Outdoor activity" were defined as outdoor activity occurring during the day only. The frequency and duration of outdoor activity were reported by the children's parents. To ensure the reliability and validity of these reports, the parental-reported outdoor activity questionnaire underwent extensive validation. We collected information on the frequency and duration of outdoor activity according to age group because children aged 0–1 year cannot walk independently, so their outdoor activity frequency and duration are dependent on their parents' activity, while those aged 1–3 years can walk independently and actively engage in outdoor activity. Following previous research [26], we conducted a categorized survey on the frequency and duration of outdoor activity.

Additionally, we assessed the test-retest reliability of the questionnaire by administering it to a subset of 100 parents at two separate time points, two weeks apart. The results indicated a high level of agreement between the two administrations, with an intraclass correlation coefficient (ICC) of 0.85 for frequency of outdoor activity and 0.82 for duration of outdoor activity, suggesting good reliability of the questionnaire.

The questionnaire included the questions concerning the outdoor activity of the children from 0 to 1 year and 1–3 years.

Q1: How often was your baby taken outside during the year of age 1? Four options were available: "1" = "<1 times/week" and "2" = "1–2 times/week" and "3" = "3–6 times/week" and "4" = "≥7 times/week".

Q2: How long per time was your baby outside on average?" Five options were available: "1" = "<30 min/session" and "2"= "30–59 min/session" and "3"= "60–89 min/session" and "4" = "90–119 min/session" and "5" = "≥120 min/session".

The questions were repeated for each age band (i.e., 0–1 year and 1–3 years). The answers were used to generate the following variables that described the children's outdoor activity during the year of age 0–1 year and 1–3 years: (1) the frequency of outdoor activity, (2) the duration of outdoor activity.

Measurement of anxiety symptoms in preschoolers (outcome variable)

Anxiety symptoms were measured using the Chinese version of the Spence Preschool Anxiety Scale (SPAS), which was modified by Chinese researchers to measure anxiety symptoms in Chinese children aged 3–6 years. This scale was chosen due to its specificity in assessing anxiety symptoms in children aged 3–6 years, which aligns with our study population. Additionally, the Chinese version of the SPAS has been adapted and tested in Chinese populations, making it a suitable tool for our study context. The scale demonstrated good reliability and validity with a Cronbach's alpha coefficient of 0.95 [1]. The scale utilizes a 5-point Likert scoring method, with response options ranging from "Never"=0, "Rarely"=1, "Sometimes"=2, "Often"=3, to "Always"=4. The scores are summed to obtain a total anxiety score ranging from 0 to 112, with higher scores indicating more severe anxiety. A total score of ≥48 is defined as a positive screening for anxiety symptoms [27].

Covariates

The following confounding covariates were included in the analysis: child's gender, single-child status, parents' education level, family's monthly income, and parental marital status.

Statistical analysis

We reported the proportions describing changes in outdoor activity frequency and duration among children aged 0–3 years as the categorical variables. Chi-square tests were used to compare the sociodemographic characteristics of children who screened positive for anxiety symptoms in preschoolers. Binary logistic regression models were employed, controlling for factors such as children's gender, family size, parental education level, household monthly income, and parental marital status, to analyze the associations between outdoor activity frequency, duration, and anxiety symptoms in preschoolers in children aged 0–1 year and 1–3 years. The Results are presented as odds ratios (ORs) with 95% confidence intervals (CI). Statistical significance was set at a two-tailed test with $P<0.05$. Data management and statistical analyses were performed using Statistical Package for the Social Sciences (version 25.0; SPSS Inc., Chicago, IL, USA).

Results

Social characteristics and anxiety symptoms

Table 1 provides an overview of participants' sociodemographic characteristics. Among the 69,571 children enrolled in the study, 2,440 (3.51%) tested positive for anxiety. Female participants exhibited a higher rate of anxiety symptoms (3.84%) compared to male participants (3.22%) ($P < 0.001$). Notably, lower parental education levels, lower economic income, being an only child, and single-parent households were identified as risk factors for child anxiety symptoms in preschoolers. These factors showed significant differences across subgroups, as detailed in Table 1.

Distribution of outdoor activity frequency and duration for children under 3 years old

The proportion of children aged 0 to 3 years with outdoor activity frequency ≥ 7 times/week decreased from 48.3% at 1 year to 42.8% at 3 years. The overall outdoor activity frequency for infants aged 0–1 year was higher than that of children aged 1–3 years (Fig. 1). An unexpected finding was that the proportion of children with a lower outdoor activity frequency (< 1 time/week) increased with age, suggesting a decline in outdoor activity as children grow older. The proportion of children aged 0 to 3 years with outdoor activity time ≥ 60 min/session increased from 54.2% at 1 year to 65.8% at 3 years. The overall outdoor activity time for infants aged 0–1 year was less than that of children aged 1–3 years (Fig. 2).

Association of outdoor activity frequency and time with anxiety symptoms in preschoolers (primary outcome)

AOR: Adjusted odds ratio. OR with adjustment for child's sex, number of children in the family, maternal and paternal education level, monthly household income, and parental marital status. *CI*: Confidence intervals. Ref: Reference. $^{*}P < 0.05$.

In children aged 0–1, outdoor activity frequency < 1 time/week, 1–2 times/week, and 3–6 times/week were found to have ORs (95% CI) for positive screening of anxiety symptoms in preschool age of 2.55 (2.22–2.94), 1.94 (1.75–2.14), and 1.19 (1.07–1.32), respectively, compared

Table 1 Social characteristics and anxiety symptoms among preschoolers

Characteristics	Total	Anxiety symptoms		χ2/F	*P*-value
		No (*N* = 67131)	Yes (*N* = 2440)		
Child's age [mean ± SD (years)]	69,571	4.9 ± 0.9	4.8 ± 0.8	0.263	0.792
Gender [n (%)]				18.894	<0.001
Male	37,073	35,878(53.4)	1195(49.0)		
Female	32,498	31,253(46.6)	1245(51.0)		
Single-child status **[n (%)]**				4.071	<0.05
Yes	47,428	45,719(68.1)	1709(70.0)		
No	22,143	21,412(31.9)	731(30.0)		
Maternal education level [n (%)]				158.784	<0.001
Junior high school or lower	10,217	9654(14.4)	563(23.1)		
High school	14,400	13,868(20.7)	532(21.8)		
College	42,646	41,362(61.6)	1284(52.6)		
Master's degree or above	2308	2247(3.3)	61(2.5)		
Paternal education level [n (%)]				86.706	<0.001
Junior high school or lower	9424	8968(13.4)	456(18.7)		
High school	14,616	14,031(20.9)	585(24.0)		
College	42,047	40,743(60.7)	1304(53.4)		
Master's degree or above	3484	3389(5.0)	95(3.9)		
Monthly household income [n (%)]				196.959	<0.001
≤¥10,000	11,630	10,982(16.4)	648(26.6)		
¥10,000–20,000	23,714	22,886(34.1)	828(33.9)		
¥20,000–30,000	14,728	14,289(21.3)	439(18.0)		
¥30,000–40,000	8066	7844(11.7)	222(9.1)		
>¥40,000	11,433	11,130(16.6)	303(12.4)		
Parental marital status [n (%)]				10.810	<0.05
Married	66,622	64,316(95.8)	2306(94.5)		
Unmarried/Divorced/	572	542(0.8)	30(1.2)		
Widowed/Remarried	2377	2273(3.4)	104(4.3)		

Means (SD) are presented for continuous variables, and N (%) is presented for non-continuous variables. Abbreviations: χ2, chi-square test. F: F variance analysis. SD: standard deviation. N (%): quantity (proportion)

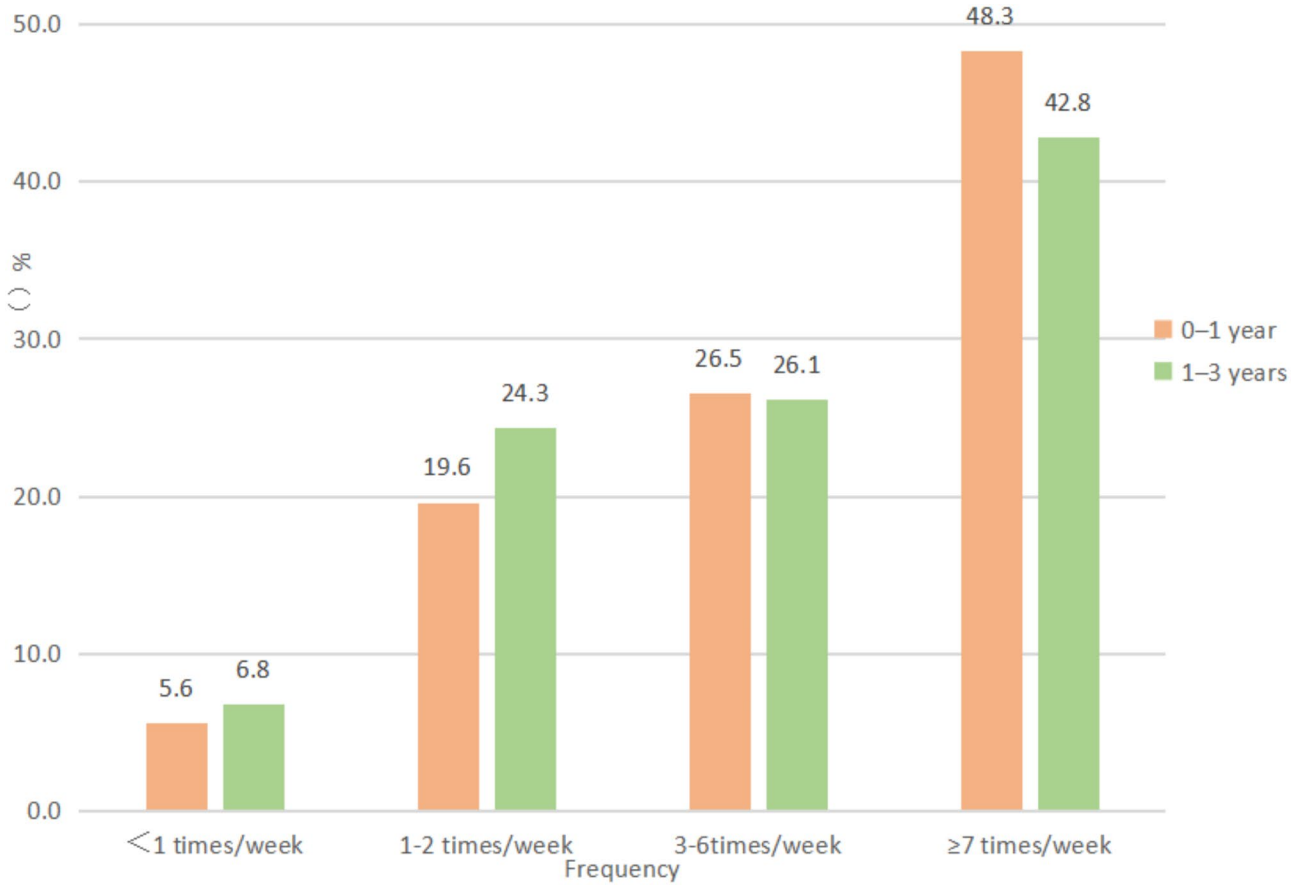

Fig. 1 Frequency of outdoor activity from 0–3 years

with outdoor activity frequency ≥ 7 times/week. Children in this age group with outdoor activity time < 30 min/session, 30–59 min/session, 60–89 min/session, and 90–119 min/session had ORs (95% CI) for positive screening of anxiety symptoms in preschool age of 1.62 (1.38–1.90), 1.33 (1.17–1.52), 1.46 (1.27–1.68), and 1.12 (0.95–1.31), respectively, compared with those with outdoor activity time ≥ 120 min/session. More detailed information is provided in Table 2.

In children aged 1–3, outdoor activity frequency of < 1, 1–2, and 3–6 times/week had ORs (95% CI) for positive screening of anxiety symptoms in preschool age of 3.10 (2.72–3.54), 1.83 (1.64–2.03), and 1.42 (1.27–1.58), respectively, compared with those with outdoor activity frequency of ≥ 7 times/week. Children in this age group with an outdoor activity duration of < 30, 30–59, 60–89, and 90–119 min/session had ORs (95% CI) for positive screening of anxiety symptoms in preschool age of 2.07 (1.73–2.48), 1.56 (1.37–1.78), 1.50 (1.31–1.72), and 1.22 (1.05–1.42), respectively, compared with those with outdoor activity time ≥ 120 min/session. More detailed information is provided in Table 3.

Discussion

We investigated the frequency and duration of outdoor activity in children aged 0–3 years, specifically in two distinct age groups: 0–1 years and 1–3 years. Our findings revealed that a lower frequency and shorter duration of outdoor activity during infancy (0–1 and 1–3 years) were associated with a higher risk of positive screening for anxiety symptoms in preschoolers. Infants and toddlers who engaged in outdoor activity at least seven times per week for at least 90 min per session during these age ranges exhibited lower levels of anxiety symptoms in preschoolers. This proves that our hypothesis is correct. There are several reasons why outdoor activity during infancy might have stronger associations with anxiety reduction compared to other periods. Firstly, infancy is a critical period for brain development, particularly in regions involved in emotional regulation and stress response [28]. During this time, the brain is highly plastic and more responsive to environmental stimuli, making it a prime window for interventions that can shape neural circuits and promote resilience to stress and anxiety [29]. outdoor activity, with their rich sensory inputs and opportunities for physical exercise, may provide the necessary stimulation to support optimal brain development

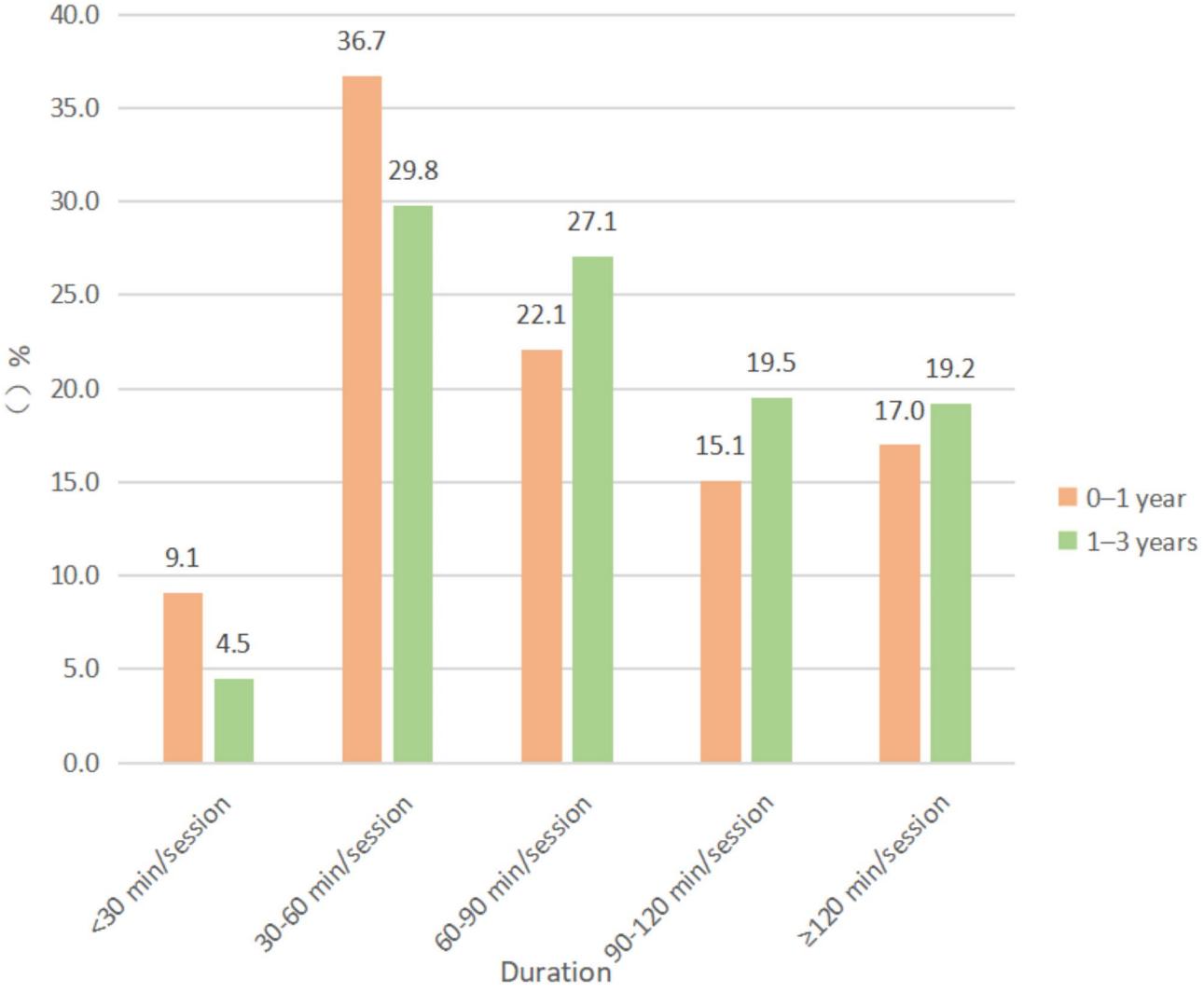

Fig. 2 Duration of outdoor activity from 0–3 years

Table 2 Outdoor activity and anxiety symptoms in preschoolers aged 0–1 year

Outdoor activity	No. of children	Cases (%)	OR (95% CI)	AOR (95% CI)
Frequency				
≥ 7 times/week	33,569	877(2.61)	Ref.	Ref.
3-6times/week	18,445	571(3.10)	1.19(1.07–1.33)*	1.19(1.07–1.32)*
1–2 times/week	13,604	707(5.20)	2.04(1.84–2.26)*	1.94(1.75–2.14)*
<1 times/week	3953	285(7.21)	2.89(2.52–3.33)*	2.55(2.22–2.94)*
Duration				
≥ 120 min/session	11,762	311(2.64)	Ref.	Ref.
90–119 min/session	10,465	311(2.97)	1.12(0.96–1.32)	1.12(0.95–1.31)
60–89 min/session	15,246	591(3.88)	1.48(1.30–1.70)*	1.46(1.27–1.68)*
30–59 min/session	25,378	908(3.58)	1.36(1.20–1.55)*	1.33(1.17–1.52)*
< 30 min/session	6720	319(4.75)	1.83(1.56–2.15)*	1.62(1.38–1.90)*

AOR: Adjusted odds ratio. OR with adjustment for child's sex, number of children in the family, maternal and paternal education level, monthly household income, and parental marital status. *CI*: Confidence intervals. Ref: Reference. *$P < 0.05$

Table 3 Outdoor activity and anxiety symptoms in preschoolers aged 1–3 years

Outdoor activity	No. of children	Cases (*N*%)	OR (95% CI)	AOR (95% CI)
Frequency				
≥ 7 times/week	29,808	705(2.37)	Ref.	Ref.
3-6times/week	18,142	610(3.36)	1.43(1.28–1.60)*	1.42(1.27–1.58)*
1–2 times/week	16,889	753(4.46)	1.92(1.73–2.13)*	1.83(1.64–2.03)*
<1 times/week	4732	372(7.86)	3.52(3.10–4.00)*	3.10(2.72–3.54)*
Duration				
≥ 120 min/session	13,277	325(2.45)	Ref.	Ref.
90–119 min/session	13,464	403(2.99)	1.23(1.06–1.42)*	1.22(1.05–1.42)*
60–89 min/session	18,717	691(3.69)	1.53(1.33–1.74)*	1.50(1.31–1.72)*
30–59 min/session	20,610	816(3.96)	1.64(1.44–1.87)*	1.56(1.37–1.78)*
< 30 min/session	3503	205(5.85)	2.48(2.07–2.96)*	2.07(1.73–2.48)*

AOR: Adjusted odds ratio. OR with adjustment for child's sex, number of children in the family, maternal and paternal age at child's birth, maternal and paternal education level, monthly household income, and parental marital status. *CI*: Confidence intervals. Ref: Reference. *$P < 0.05$

in these domains. Secondly, outdoor activity during infancy offer unique opportunities for social interaction and emotional support, which are crucial for the development of secure attachment relationships and the regulation of emotions [30]. Infants and toddlers who engage in regular outdoor activity are more likely to interact with caregivers and peers in positive and supportive ways, fostering a sense of safety and trust that can mitigate the risk of anxiety later in life.Thirdly, exposure to natural light and outdoor environments has been shown to have profound effects on mood and anxiety levels across the lifespan, but these effects may be particularly pronounced during infancy when the circadian system is still maturing [31].

Previous research has shown that the provision of more outdoor activity spaces is associated with lower anxiety levels in children in a given area. The attractiveness of outdoor environmental features reduces anxiety in children. These studies highlighted the importance of adequate outdoor activity facilities for children's physical and mental health. However, these studies did not make recommendations regarding the timing or frequency of outdoor activity in early childhood, which we aimed to elucidate. Our study provides recommendations for the frequency and duration of outdoor activity in early childhood. A meta-analysis conducted in the US found that nature-based outdoor activity were beneficial for the psychological well-being of adults, with the most effective intervention duration ranging from 8 to 12 weeks and an optimal duration range of 20 to 90 min [25]. Currently, most studies on the impact of outdoor activity on mental health have focused on older children or adults, and there is limited research on the effects of outdoor activity on the mental health of young children [32]. Children are in a phase of rapid growth and development that makes them more sensitive to environmental influences [33]. Building on this knowledge, our study demonstrates an association between the frequency and duration of outdoor activity in early childhood and children's anxiety symptoms. Increasing the frequency and duration of outdoor activity for infants and toddlers may be an effective approach for reducing anxiety levels, which is an important consideration for the scientifically informed upbringing of children [34]. Studies have shown that children spend less time outdoors as they age [35, 36]. Our study found that the frequency of outdoor activity decreased with age, but the time spent outdoors increased.

Previous studies have found that exposure to sunlight and outdoor views may be responsible for lower anxiety levels. Ultraviolet (UV) radiation is a major component of sunlight, and previous studies have confirmed that moderate exposure to UV radiation can have beneficial effects on human mood [37]. Another study revealed that the activity of striatal dopamine D2/D3 receptors was significantly higher in a high-sunlight exposure group than in a low-sunlight exposure group [38]. Increasing the frequency and duration of outdoor activity provides infants and toddlers with more opportunities for sunlight exposure, which may contribute to reduced anxiety. In addition, exposure to natural environments during outdoor activity is beneficial for reducing anxiety. A study of older adults showed that exposure to natural scenery improves mood, with the greatest effect of 80–90 min spent outdoors in natural settings [39]. Furthermore, spending a minimum of 120 min/week in nature is associated with lower anxiety and higher happiness levels [40]. A study on six healthy middle-aged individuals found a positive correlation between time spent outdoors and the volume of gray matter in the right dorsolateral prefrontal cortex from multiple magnetic resonance imaging (MRI) brain scans, as well as positive affect and decreased anxiety levels [41].

In addition, outdoor activity can attract children's attention through games, temporarily divert their attention from anxious emotions, and provide them with pleasant emotional experiences. Studies have shown a correlation between increased outdoor activity and more

play space for children [42–44], and play has been found to reduce children's anxiety symptoms. Compared to indoor activity of a similar nature, outdoor activity are associated with higher levels of happiness and lower levels of stress and anxiety [45]. Another study involving 54 preschoolers found that after a 10-week outdoor activity-based intervention focused on "play and growth," the children reported a decrease in perceived stress [46].

The main strength of this study is that it adds to the evidence on the relationship between outdoor activity and anxiety symptoms in younger children. Whereas previous studies have made no recommendations regarding the frequency and duration of outdoor activity in early childhood, our study helps to fill this gap by providing specific recommendations regarding the frequency and duration of outdoor activity in young children. Using data from a large sample size, our study found that frequency of outdoor activity ≥ 7 times/week and duration of ≥ 120 min per time during infancy were associated with lower levels of anxiety symptoms in preschoolers. These findings provide parents with valuable insights and support the importance of outdoor activity frequency and duration in preventing childhood anxiety symptoms. However, our study does have certain limitations. First, data on the frequency and duration of outdoor activity were collected retrospectively, relying on parental reports, which may have introduced significant recall bias. To mitigate this issue in future research, the use of prospective designs, such as daily diaries or activity trackers, could provide more accurate and reliable data on outdoor activity. Additionally, including objective measures, like GPS data or wearable devices, could further reduce recall bias and enhance the validity of the findings. Second, our study was a cross-sectional survey that could only establish associations between outdoor activity frequency and duration and anxiety symptoms in preschoolers. It does not provide evidence of causality. Third, our study focused exclusively on outdoor activity outside of daycare settings and did not measure the time spent at daycare or the duration of outdoor activity when children are at daycare. This could be an important covariate that may influence the association between outdoor activity and anxiety symptoms in preschoolers. It is worth noting that in China, the number of infants aged 0–3 years attending daycare is relatively small compared to other countries, due to cultural and societal factors. Future studies in China should consider including these variables to provide a more comprehensive understanding of the relationship, taking into account the unique childcare context in our society. Fourthly, different cultural backgrounds, climatic conditions, levels of urbanization, and the availability of outdoor spaces may influence the association between outdoor activity in early childhood and anxiety symptoms in preschoolers. For example, in cultures where outdoor activity are more highly valued and readily accessible, the benefits of outdoor activity in reducing anxiety may be more pronounced. Conversely, in environments with limited outdoor spaces or safety concerns, this relationship may be weakened. To better understand these potential moderating factors, further research is needed across diverse cultural and environmental contexts.

Conclusion

Lower frequency and shorter duration of outdoor activity during infancy (0–1 and 1–3 years) had higher odds of screening positive for anxiety symptoms in preschoolers. A frequency of ≥ 7 outdoor activity per week and a duration of ≥ 120 min/session during infancy were associated with lower levels of anxiety symptoms in preschoolers. These findings provide actionable insights for parents and caregivers, highlighting the importance of promoting outdoor activity in early childhood care and parenting practices. Future studies should further explore the causal relationship between outdoor activity and the prevention of anxiety.

Abbreviations

AOR	Adjusted Odds Ratio
CI	Confidence Interval
LCS	Longhua Children's Study
OR	Odds Ratio
SD	Standard Deviation
SPAS	Spence Preschool Anxiety Scale
SPSS	Statistical Package for the Social Sciences
UV	Ultraviolet

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12888-025-06831-2.

Supplementary Material 1

Acknowledgements

The authors would like to show their gratitude to the families who participated in the study, the doctors from Longhua Maternal and Child Healthcare Center, and the kindergarten teachers who took part in the investigation.

Author contributions

Conceptualization: Jian-Bo and Yan Zhang. Data curation: Jian-Bo, Dali Lu and Yuying Zhang. Formal analysis: Jian-Bo Wu and Dali Lu. Funding acquisition: Jian-Bo Wu, Yanni Yang, Qiang Zhou, Yuying Zhang, and Jing-Yu Zhang. Investigation:. Methodology: Shuang-Yan Qiu and Fang Zhou. Project administration: Jian-Bo Wu, Dali Lu and Ziyi Zhao. Resources: Jian-Bo Wu and Danxia-Xian. Software: Guo-Ming Wen and Yan Zhang.Supervision: Dali Lu. Validation: Dali Lu and Jiemin Li. Visualization: Yuying Zhang. Writing–original draft: Jian-Bo Wu, Yan Zhang and Jing-Yu Zhang. Writing–review and editing: Jian-Bo Wu, Yan Zhang.

Funding

Funding was provided by the Longhua District Medical And Health Institutions Regional Scientific Research Project (2022086); Longhua District Medical And Health Institutions Regional Scientific Research Project (2021043); Medical Key Discipline Construction Fund of Longhua District.

Data availability
Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the ethical standards of the School of Public Health, Sun Yat-sen University. Ethical approval was obtained from the Ethics Committee of the School of Public Health, Sun Yat-sen University (Ethics Approval No: 2021 – 116). All participants' parents provided informed consent prior to their participation in the study.

Consent for publication
The manuscript does not contain any individual person's data in any form (including any individual details, images, or videos). Therefore, consent for publication is not applicable to this study.

Competing interests
The authors declare no competing interests.

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Received: 20 March 2024 / Accepted: 8 April 2025
Published online: 17 April 2025

References

1. Wang M, Zhao J. Anxiety disorder symptoms in Chinese preschool children. Child Psychiatry Hum Dev. 2015;46(1):158–66.
2. Petresco S, et al. Prevalence and comorbidity of psychiatric disorders among 6-year-old children: 2004 Pelotas birth cohort. Soc Psychiatry Psychiatr Epidemiol. 2014;49(6):975–83.
3. Kessler RC, et al. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National comorbidity survey replication. Arch Gen Psychiatry. 2005;62(6):593–602.
4. Merikangas KR, et al. Lifetime prevalence of mental disorders in U.S. Adolescents: results from the National comorbidity survey Replication–Adolescent supplement (NCS-A). J Am Acad Child Adolesc Psychiatry. 2010;49(10):980–9.
5. Kertz SJ, et al. Latent class profiles of anxiety symptom trajectories from preschool through school age. J Clin Child Adolesc Psychol. 2019;48(2):316–31.
6. Bosquet M, Egeland B. The development and maintenance of anxiety symptoms from infancy through adolescence in a longitudinal sample. Dev Psychopathol. 2006;18(02):517–50.
7. Bufferd SJ, et al. Psychiatric disorders in preschoolers: continuity from ages 3 to 6. Am J Psychiatry. 2012;169(11):1157–64.
8. Cartwright-Hatton S, McNicol K, Doubleday E. Anxiety in a neglected population: prevalence of anxiety disorders in pre-adolescent children. Clin Psychol Rev. 2006;26(7):817–33.
9. Cote SM, et al. Depression and anxiety symptoms: onset, developmental course and risk factors during early childhood. J Child Psychol Psychiatry. 2009;50(10):1201–8.
10. Whalen DJ, Sylvester CM, Luby JL. Depression and anxiety in preschoolers: A review of the past 7 years. Child Adolesc Psychiatr Clin N Am. 2017;26(3):503–22.
11. Chisholm D, et al. Scaling-up treatment of depression and anxiety: a global return on investment analysis. Lancet Psychiatry. 2016;3(5):415–24.
12. Ding X, et al. Individual, prenatal, perinatal, and family factors for anxiety symptoms among preschool children. Front Psychiatry. 2021;12:778291.
13. Ehrenberg D, et al. How anxious are German preschool children?? Child Psychiatry Hum Dev. 2022;53(5):992–1003.
14. Predy M, Holt N, Carson V. Examining correlates of outdoor play in childcare centres. Can J Public Health. 2021;112(2):292–303.
15. Wu JB, et al. Association between screen time and hyperactive behaviors in children under 3 years in China. Front Psychiatry. 2022;13:977879.
16. Larson LR, Green GT, Cordell HK. Children's time outdoors: results and implications of the National kids survey. J Park Recreation Adm. 2011;29(2):1–20.
17. Hofferth SL. Changes in American children's time– 1997 to 2003. Electron Int J time Use Res. 2009;6(1):26–47.
18. CLEMENTS. An investigation of the status of outdoor play. Contemp Issues Early Child. 2004;5(1):68–80.
19. Larouche R, et al. Outdoor time, physical activity, sedentary time, and health indicators at ages 7 to 14: 2012/2013 Canadian health measures survey. Health Rep. 2016;27(9):3–13.
20. Bao Y, et al. The influence of outdoor play spaces in urban parks on children's social anxiety. Front Public Health. 2022;10:1046399.
21. Hian S et al. Vertical greenery buffers against stress: evidence from Psycho-physiological responses in virtual reality. Landsc Urban Plann, 2021. 213(16).
22. Lee E, Maillet M, Grouzet FME. Why do individuals engage with the natural world?? A Self-Determination theory perspective on the effect of nature engagement and quality of life. Applied Research in Quality of Life; 2021.
23. Battaglia G et al. Influence of a specific aquatic program on social and gross motor skills in adolescents with autism spectrum disorders: three case reports. J Funct Morphol Kinesiol, 2019. 4(2).
24. Tabacchi G, et al. Food literacy predictors and associations with physical and emergent literacy in pre-schoolers: results from the Training-to-Health project. Public Health Nutr. 2020;23(2):356–65.
25. Coventry PA, et al. Nature-based outdoor activities for mental and physical health: systematic review and meta-analysis. SSM Popul Health. 2021;16:100934.
26. Huang L, et al. Combination effect of outdoor activity and screen exposure on risk of preschool myopia: findings from Longhua child cohort study. Front Public Health. 2021;9:607911.
27. Hu H, et al. Association between family structure and anxiety disorder among Pre-schoolers: A Cross-Sectional study in urban Chongqing, China. Front Psychiatry. 2021;12:626377.
28. Knudsen EI. Sensitive periods in the development of the brain and behavior. J Cogn Neurosci. 2004;16(8):1412–25.
29. Shonkoff JPE. From neurons to neighborhoods: the science of early childhood development. Australian New Z J Psychiatry. 2000;41(5):625–6.
30. Emma L et al. The relationship between the physical activity environment, nature relatedness, anxiety, and the psychological Well-being benefits of regular exercisers. Front Psychol, 2017. 8.
31. Lambert GW, et al. Effect of sunlight and season on serotonin turnover in the brain. Lancet. 2002;360(9348):1840–2.
32. Larouche R, Garriguet D, Tremblay MS. Outdoor time, physical activity and sedentary time among young children: the 2012–2013 Canadian health measures survey. Can J Public Health. 2017;107(6):e500–6.
33. Gascon M, Vrijheid M, Nieuwenhuijsen MJ. The built environment and child health: an overview of current evidence. Curr Environ Health Rep. 2016;3(3):250–7.
34. Lau WY, et al. Effectiveness of group cognitive-behavioral treatment for childhood anxiety in community clinics. Behav Res Ther. 2010;48(11):1067–77.
35. Cleland V, et al. Predictors of time spent outdoors among children: 5-year longitudinal findings. J Epidemiol Community Health. 2010;64(5):400–6.
36. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. Med Sci Sports Exerc. 2000;32(5):963–75.
37. Beecher ME, et al. Sunshine on my shoulders: weather, pollution, and emotional distress. J Affect Disord. 2016;205:234–8.
38. Tsai HY, et al. Sunshine-exposure variation of human striatal dopamine D2/D3 receptor availability in healthy volunteers. Prog Neuropsychopharmacol Biol Psychiatry. 2011;35(1):107–10.
39. White PC, et al. Exposure to nature gardens has time-dependent associations with mood improvements for people with mid- and late-stage dementia: innovative practice. Dementia. 2017;17(5):1471301217723772.
40. White MP, et al. Spending at least 120 minutes a week in nature is associated with good health and wellbeing. Sci Rep. 2019;9(1):7730.
41. Kuhn S, et al. Spend time outdoors for your brain - an in-depth longitudinal MRI study. World J Biol Psychiatry. 2022;23(3):201–7.
42. Rubin KH, Coplan R. The development of shyness and social withdrawal. Guilford; 2010.
43. Veitch BTA. Children's ratings of park features that encourage park visitation, physical activity and social interaction. Volume 58. Urban Forestry & Urban Greening; 2021. 1.

44. Zhang RCWP. The neighborhood socioeconomic inequalities in urban parks in a High-density City: an environmental justice perspective. Landsc Urban Plann, 2021. 211(1).
45. Thompson CJ, et al. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. Environ Sci Technol. 2011;45(5):1761–72.
46. Sobko T, et al. Impact of outdoor nature-related activities on gut microbiota, fecal serotonin, and perceived stress in preschool children: the play&grow randomized controlled trial. Sci Rep. 2020;10(1):21993.

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