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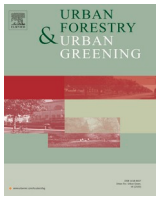

Strengthening the pedagogical use of the outdoor area at nature-based daycare centers: An intervention study

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ABSTRACT

Nature-based daycare centers offer young children valuable opportunities to establish a meaningful connection with the natural world. These opportunities frequently remain underrealized as caregivers often lack adequate skills in effectively integrating the natural environment into their daily pedagogical practices. This study evaluated the impact of a one-year Community of Practice training program to enhance the pedagogical use of the outdoor area of nature-based daycare centers. It examined the impact of the program on children's stress levels, wellbeing, involvement, and behavior in the outdoor area, among a total sample of 133 children aged 0–4 years. The program aimed at strengthening caregivers' pedagogical interaction skills in the outdoor area with a focus on vulnerable groups including the youngest and oldest children and boys. Measures of children's hair cortisol, and observations of wellbeing, involvement, physical activity, social behavior and play behavior during free play in the natural outdoor playground were collected post-program at 6 intervention and 7 control locations. Results indicate positive impacts of the program for boys in terms of their stress levels, wellbeing, involvement, physical activity, and creative play behavior. Youngest children at interventions showed more functional play behavior, while the oldest children showed more creative play. Children at locations with a high-quality outdoor area seemed to benefit more from the intervention than children at locations with a low-quality outdoor area. These findings underscore the importance of the pedagogical use of the outdoor natural area as a contributor to the effectiveness of nature-based daycare, alongside considerations of environmental qualities.

1. Introduction

In today's fast-paced world, many young children spend a significant portion of their time in daycare centers, often starting at a very early age. This development has raised concerns about how these environments influence children's wellbeing. In particular, parents and caregivers have expressed concern about whether daycare centers provide sufficient opportunities for young children to make contact with the natural world as an essential aspect of early childhood development (Verstrate and Karsten, 2015). In response to these concerns, many facilities have begun to integrate natural elements into their outdoor environment (Puhakka et al., 2019). At these nature-based daycare centers, children spend a large amount of their time outdoors in nature. However, mere exposure to nature may not be sufficient for children to reap the benefits of nature (Richardson et al., 2021). Children need to actively engage with nature in an autonomous manner to build a deeper connection with nature that supports their well-being throughout the lifespan and inspires them to take responsibility to care for nature and the planet (Chawla, 2020). Against this background, professional development of pedagogical staff on how to utilize the outdoor play and learning environment constitutes a key challenge for early childhood education and care (ECEC) (Cooper, 2015). To address this challenge, we conducted a Community of Practice program for staff of nature-based daycare centers aimed at strengthening the pedagogical use of the outdoor natural area. In this paper, we describe the results of an evaluation of this program on children's stress, wellbeing, involvement and play behavior.

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1.1. The importance of nature in early childhood

Childhood is a critical period in which humans make a connection to other living beings in the natural world (Kahn and Kellert, 2002). While most research on children's connectedness to nature has focused on children in the school age (6–12 years), there are indications that the foundations of the human bond with nature are already laid at a very early age, when children start to explore their environment with all their senses (Rice and Torquati, 2013). Through active sensory engagement with their surroundings, young children are encouraged to interact, explore, transform, and care for the natural environment, harnessing all their senses and physical capacities (Brussoni et al., 2015). In general, children have a strong intrinsic motivation to affiliate with nature early in life, which is, among other things, shown by the popularity of animals and nature in children's books (Moore and Cooper-Marcus, 2008).

A growing body of evidence shows that connectedness to nature is positively associated with many aspects of healthy child development (Chawla, 2020; Richardson et al., 2019). For example, one study found that very young children with high parent-rated levels of connectedness to nature had higher scores on the Strengths and Difficulties Questionnaire, a widely used measure of young children's social and emotional health (Sobko et al., 2018). Across different age groups, children with more opportunities to engage with and connect to nature tend to display a better mood and mental health, more self-esteem and better self-regulation and motor skills, more pro-social and creative play behaviors, and better attention skills (see for reviews, (Dankiw et al., 2020; Fyfe-Johnson et al., 2021; Johnstone et al., 2021; Mygind et al., 2021; Putra et al., 2020; Tillmann et al., 2018; Vanaken and Danckaerts, 2018; Weeland et al., 2019).

Apart from the immediate benefits on children's health and well-being, there may also be life-long positive impacts of childhood nature experiences. Retrospective studies have, for example, revealed that adults who engaged in nature-based activities at a young age exhibit more life satisfaction and more pro-environmental behaviors and attitudes later in life (Pensini et al., 2016; Wells and Lekies, 2006). This pathway from childhood nature experiences to adult well-being and environmentalism is believed to entail a gradual process. Children initially form attachments through active engagement with nature nearby, gradually extending these feelings to encompass nature at large. In adults, this connection to nature translates into greater happiness and pro-environmental behavior, suggesting a potential 'happy path to sustainability' founded on fostering children's affinity with nature (Nisbet and Zelenski, 2011).

1.2. Nature-based daycare

Nature-based daycare supports children in making a connection with nature in the earliest years of their lives. The concept dates back to the 1950 s and 60 s, when parents in Denmark, Germany and other Scandinavian countries, enthused by the writings of Thoreau, Muir and other philosophers, and inspired by their own early childhood experiences with nature, took the initiative to establish forest preschools (also called Waldkindergarten in Germany, or Naturbørnehavens in Denmark) (Ulset et al., 2017). At forest preschools, which can still be found in many countries across the world, children spend several (or sometimes even all) days a week outdoors in nearby natural areas, with limited or no indoor facilities (Harwood et al., 2017; Leather, 2018).

In recent years, a different approach to nature-based daycare has emerged, with growing numbers of daycare centers taking the initiative to green their outdoor play area with grass, bushes, trees, water bodies, sand pitches and other types of natural features (Verstrate and Karsten, 2015). At these daycare centers, children can experience nature on the center's own premises. A key difference with forest schools is that the outdoor areas are not naturally grown, but designed by landscape architects and other professionals. Besides natural features, the play areas typically also contain nature-inspired play equipment, like mud kitchens, willow arches, jungle gyms, climbing structures made of wood, and rock tunnels. Another difference with forest schools is that pedagogical staff, mostly young women, often has not been trained or educated on how to optimally use the natural play area in their daily pedagogical practices. According to experiences of professionals working in green daycare, shared with the research team, much of the staff tends to consider time outdoors mostly a break, during which there is time to chat with colleagues and drink a cup of tea or coffee. If more actively involved, they tend to be (too) directive, guiding children in their play behavior, instead of letting the loose materials and affordances of the natural environment guide the children.

1.3. Strengthening pedagogical use

The concept of attentive presence, which was originally developed in the field of healthcare (Klaver and Baart, 2011), provides a useful starting point for improving the pedagogical use of nature in daycare. Following this approach, caregivers are stimulated to be fully present on what is happening in the moment, accept what is happening as it is, and have eye for how the child is captured and guided by affordances in the environment, and support the child in doing so. Training staff to be more attentively present may be especially helpful for boys, who have been identified as a high-risk group exhibiting more problem behavior than girls in early childcare settings (De Schipper et al., 2004). This gender difference has been attributed to the more feminine interaction style that is common for both female and male caregivers in daycare (Van Polanen et al., 2017; Wernersson, 2015).

Older children (preschoolers) who are ahead of the younger children in their development and who are about to enter primary school, are also more likely to experience stress in daycare because the pedagogical program of the centers is not tailored to meet their needs for more cognitive stimulation (Keenan and Shaw, 1997). Being guided by staff that lets them move around freely and supports them in making sense of the environment may also benefit this group (Bowlby, 2007). The same might apply to the very youngest (babies and toddlers) who are often not even allowed to spend time outdoors in a relatively independent manner. In general, a pedagogical approach in which children are allowed to spend time exploring the environment on their own with staff attentionally present may be especially beneficial for boys and the youngest and oldest age groups.

1.4. Collaboration in action as an approach to stimulate pedagogical use of nature

Changing professional practices is a complex and challenging task (Hargreaves and Fullan, 2015). Even when change is perceived as needed or beneficial, mixed feelings about the change process can cause individuals to resist. Collaborative action provides a way for staff of daycare centers to achieve professional change through working in Communities of Practices (COPs) with each other and external researchers, experts, and facilitators as part of the community (Sagor, 2010). It involves a recursive, spiral cycle of inspiring, planning, acting, observing, reflecting, re-inspiring, re-planning, and re-enacting. It also requires a commitment of all partners to knowledge development (Mertler, 2019). After each step in the cycle, professionals reflect on their experiences and share their reflections with the other members. Professionals also become researchers by evaluating the effects of new tasks or approaches. In addition to this 'within-program' knowledge development, it is important to collect objective data on the 'post-program' impact of the COP on children as the end-users of the program. Such evaluations can provide a justification for the implementation of a COP program.

1.5. The present research

The present research evaluated the impacts of a collaborative action COP program to strengthen the pedagogical use of outdoor areas at nature-based daycare centers on stress, wellbeing, involvement, and

play behavior of children aged 0–4 attending daycare. Few studies on children and nature have thus far looked at such a young age group.

Given their limited capacity for verbal exchanges, research with very young children requires the use of implicit and observational measures. Following this consideration, the impacts of the COP program were evaluated using (a) hair cortisol concentrations as a non-invasive indicator of stress levels in the past four months (Groeneveld et al., 2013; Russell et al., 2012), (b) observations of children's wellbeing and involvement during free outdoor play (Laevers et al., 2005), and (c) observations of play behavior (including non-play, social behavior and physical activity) in the outdoor natural area as additional measures for children old enough to move around independently (Rubin, 2001). For each of the outcome variables, we looked at potentially greater positive impacts of the COP program for vulnerable groups, including the youngest and oldest children, and boys. We also examined possible differences between daycare centers with a low and high quality of the outdoor area.

2. Method

2.1. Daycare centers

Participating daycare centers were all certified by branch organization of nature-based daycare Green Cement, and they were recruited via this organization. First, daycare centers were invited to participate in the COP program. Next, potential control locations that matched the intervention centers in characteristics like size and urbanity were approached. Our original research protocol included 24 daycare centers, divided into 12 intervention locations that participated in a COP program for strengthening the pedagogical use of the outdoor environment, and 12 matched control centers that did not participate in such a program. All 12 intervention locations completed the COP program, but due to Corona restrictions we were only able to visit 6 of the intervention locations and 7 of the control locations afterwards to evaluate the impact on children's stress levels, wellbeing, involvement, physical activity, social behavior and play behavior. As a result, the centers that participated in this evaluation study were not as well-matched as was originally planned.

The final number of 13 daycare centers that participated in this study were assessed on the following characteristics:

Urbanity and size: These characteristics were derived from objective geographical data provided by the Dutch Bureau of Statistics and the National Land Registry, using common classifications based on the postal code of the locations.

Naturalness and quality of the outdoor environment. During their visits to the locations the researchers assessed the naturalness and quality of the outdoor area. Naturalness was assessed by giving an estimate of the percentage of the outdoor area covered by greenery and other natural elements. These estimates were divided into three broad classes: Low (40–60%), medium (60–80%) and high (>80%). Quality of the outdoor environment was assessed on-site using an adapted 12-item version of the checklist for the quality of daycare centers by branch organization Green Cement. Sample items are: "is suitable to explore with all senses", "contains loose natural materials", and "There are places for children to hide"(see for all items Table A2 in Appendix A). Each item was scored on a 4-point scale ranging from 0 = low quality to 4 = high quality. Reliability of the scale was good, Cronbach's alpha = .94. Scores were divided in two categories of relatively low and high quality based on scores higher and equal or lower than 3.

Fig. 1 gives an impression of the outdoor areas at the participating centers with close-ups of places for children to hide.

Table 1 gives an overview of the characteristics of intervention and control locations. Intervention locations are more often located in highly urban areas and have smaller outdoor areas. However, despite their smaller size, all intervention locations have a high-quality outdoor area with abundant affordances and loose parts. Intervention locations and control locations are similar in naturalness, with the majority of centers in both groups having a predominantly natural outdoor area that is covered for more than 80% with vegetation and natural elements (shrubs, trees, plants, grass, trees, vegetable gardens, water features, animals, tree trunks).

Fig. 1. Impressions of the outdoor area at nature-based daycare centers that participated in the study with overviews of the areas in the top panel, and close-ups of features that afford opportunities to hide, alone or with peers. (all photos reproduced with copyright permissions).

Table 1
Characteristics of intervention and control locations.

Characteristic	Control	Intervention
Nr. of locations	7	6
Urbanity		
Low	5 (71.4%)	0 (0.0%)
Moderate	1 (14.3%)	4 (66.7%)
High	1 (14.3%)	2 (33.3%)
Size outdoor area		
Small (< 350 m^2)	1 (14.3%)	4 (66.7%)
Medium (350-850 m^2)	2 (28.6%)	1 (16.7%)
Large (≥ 850 m^2)	4 (57.1%)	1 (16.7%)
Naturalness		
40-60% vegetation	1 (14.3%)	1 (16.7%)
60-80% vegetation	1 (14.3%)	1 (16.7%)
> 80% vegetation	5 (71.4%)	4 (66.7%)
Quality outdoor area		
Mean score/SD	3.20 (0.85)	3.69 (0.31)
Score > 3	4 (57.1%)	6 (100%)

2.2. Children

The final study population consisted of 133 children, aged 0–4 years. Data on wellbeing and involvement were complete for 111 children. Data on physical activity and play behavior were complete for 96 children. Because not all parents gave permission to cut off a piece of their child's hair, hair cortisol was collected for a smaller sample of 79 children. In this latter group, there were incomplete data for age. Table 2 gives an overview of the characteristics of children at intervention and control locations in the three subsamples.

There are less children in the intervention than in the control groups. However, for each of the three subsamples, the two groups are similar in age and gender distribution. Crosstabs analyses for each of the three subgroups revealed that within the control and intervention groups, there are no significant differences in the distribution of girls and boys across age groups, *ps* > .31. This indicates that impacts of age and gender can be examined independently.

2.3. Intervention

For each of the intervention locations, a Community of Practice (COP) was formed, consisting of 5–16 pedagogical staff members and managers, a member of the research team, and an expert from the branch organization of nature-based daycare or a nature education organization. The COP program included four meetings of half-a day, held over a period of a year, in which staff were stimulated to reflect on the pedagogical quality of the proposed outdoor activities and ideas in relation to different target groups the presupposed effect, and the practical feasibility in daycare. The details of the COP program are described elsewhere (Joven and Hovinga, 2017). Below we give a brief summary.

The general apprgaroach of the COP program was focused on strengthening caregiver interactive skills (Helmerhorst et al., 2014) in relation to the use of the outdoor play area. In particular, staff was stimulated to be 'attentively present' (Klaver and Baart, 2011). The meetings were combined with 'homework' assignments for staff to try out and evaluate the activities in the three months between each meeting. For example, as one of the assignments, staff were asked to make video clips with their phone of moments in which they interacted with the children, and write a reflection on how they see themselves interacting with the children and discuss their insights with the group.

The COP program started with a kick-off meeting during which the staff members were informed about the program and the research. The next four meetings each started with a reflection and evaluation of the activities and innovation development by the staff as well as the researchers. This was followed by an inspiration session in which experts provided examples of possible outdoor activities for age groups 0–4 and ideas for the design of the outdoor space, materials, activity forms and organizational skills. The meetings ended with the formulation of a new action plan. Staff who participated in the COP program were stimulated to share their insights and experiences with their co-workers at the daycare center to set into motion a process of taking responsibility and self-management.

Table 3 gives an impression of the activities developed by the staff during the program, as shared in their reflections of the video they made of themselves interacting with the children while trying out the activities.

2.4. Child measures

Within two months after the COPs were completed, six daycare centers that participated in the COP program and seven control locations that did not participate were visited by two members of the research team. During the visit, the following measures were obtained from children who had parental permission to participate:

Hair cortisol. Cortisol is a well-known implicit hormonal measure of stress, as a final product of activation of the hypothalamic–pituitary–adrenal axis. Cortisol levels have been determined mostly in blood or saliva, which is not suitable for young children. Measurement of cortisol in human scalp hair provides an alternative non-invasive way of measuring long-term stress in young children. Children's hair samples were collected following standard procedures and sent to the Institute of Biopsychology, TU Dresden, where they were analyzed for concentrations the stress hormone cortisol during the past four months using an immunoassay kit with chemiluminescence detection (see (Kirschbaum et al., 2009), for a detailed description of the process). Visits to the daycare centers took place about 2 months after the last COP meeting, thus hair cortisol concentrations roughly represent the four months around the end of the COP program. Hair cortisol concentrations for the three- and four-month back segments could not be determined for 9 children, because their hair was not long enough. To address positive skewness, natural log transformations of concentrations for each of the four one-month segments were used for analysis.

Wellbeing and Involvement. Children's wellbeing and involvement were assessed during the second minute of observation using the SICs (ZiKo) instrument (Laevers et al., 2005). The instrument can be applied to all children, including the very young, and distinguishes five

Table 2
Characteristics of three subsamples of children at daycare centers in the intervention and control group.

	Wellbeing/Involvement		Play/Social/Physical Activity		Hair Cortisol	
Characteristic	Control	Intervention	Control	Intervention	Control	Intervention
Nr. of locations	7	6	7	5	7	6
Nr. of children	69	42	69	27	43	36
Nr. of girls	32 (46.4%)	19 (45.2%)	30 (44.8%)	14 (48.3%)	20 (46.5%)	18 (50.0%)
Age group						
4-18 months	9 (13.0%0	6 (14.3%)	10 (14.9%)	5 (18.5%)	9 (20.9%)	5 (13.9%)
18-36 months	34 (49.3%)	20 (47.6%)	39 (58.2%)	16 (59.3%)	21 (48.8%)	16 (44.4%)
36-48 months	26 (37.7%)	16 (38.1%)	18 (26.0%)	8 (29.6%)	12 (27.9%)	10 (27.7%)
unknown	-	-	-	-	1 (2.3%)	5 (13.8%)

Table 3
Activities developed by staff of intervention centers to improve interaction skills in the outdoor space, as described in staff's own words while describing video clips of their interactions (translated from Dutch).

Activities for babies and toddlers
Exploring nature: *I am outside with 2 babies (9 and 10 months) under the pergola in the play corner for the babies. One boy is an active little boy and immediately goes to investigate. The other guy first looks around calmly and picks up some leaves and twigs to put in his mouth.* (description # 11.1)
Tactile board: *We are sitting in the baby garden and I have hung up the tactile board. I sat down and then 3 toddler-aged children joined us. Together we go through all the boxes on the tactile board and feel and name them. It contains materials of: stones, rope, mop, shells, nuts, tile, other stones and felt flowers. The flowers they touched were now coming loose and they were neatly released into my hands. I'll have to put this back on again.* (description # 24.1)
Activities for boys
Water fun: *Lunchtime with 8 children (6 boys) in the garden. We play with loose wood discs and create a course together. If you fall off you will be in the water and we all want to go to the island together. The children participate enthusiastically. Only one child first watches from a distance.* (description # 8.1).
Lifting stones: *I'm at the hill. There are large boulders and stones on the hill. These are normally not there. A little boy notices this immediately. "What is this?" Then we start a conversation. We are talking about the differences in stones. Boy indicates that there are big ones and small ones. I ask if he can lift the big one. Wow. He can do this! He can lift two of the little ones. He is proud.* (description # 19.1)
Activities for older children
Naming objects: *I look in the sandbox with a child to see what is there, we start very seriously to name what is there. We also look at the mud kitchen. There are two of us there. We have a chat together* (description # 20.1).
Splashing the mud: *We are* in the backyard, there is a lot of mud and puddles due to the *rain. It is around noon that most of the younger children sleep. It is dry and I take three older children outside. They collect tree trunks from the puddles and then throw them into them hard, the water splashes in all directions. They even jump in the puddles. Everyone is completely wet and their faces are covered in mud. My pants and shoes are also wet and full of mud.* (description # 33.1)
General activities
Planting a berry bush: *We are in our garden together with about 10 children of all ages; we have just discussed where the berry bush will be planted. Everyone gets a shovel or rake; I film, while my colleague instructs the children. Together we compliment what they are doing and 'mirror' what we see to the children. We also set boundaries together while shoveling and planting is taking place. The children are very involved, find it very interesting, educational and want to help. At the end, a watering can is filled with water and the bush is watered.* (description # 42.1).
Earthworm: *We are outside in the front garden with 5 children. […]. The children give dried apples from the tree to the chickens in the coop. Then a child comes to me from the other side of the garden. Excited because she found an earthworm. She holds it carefully in her hand. We talk about the worm; watch how he moves. Pass the worm to each other. Not every child dares to do this. We do not feed the worm to the chickens. But end the activity by collecting leaves and covering the soil after we have put the worm back on the soil.* (description # 33.1)

levels of wellbeing and involvement, ranging from 1 = very low to 5 = very high (see Table A1 in Appendix A for a description of the levels).

Physical Activity. The level of physical activity during the play observation period was assessed using a three-point scale with categories 1 = sedentary, 2 = moderate, 3 = intensive.

Play Behavior. Within the first minute of the observation period, play behavior was coded using the five cognitive play categories from the Play Observation Scale (POS, (Rubin, 2001): functional play, games-with-rules, constructive play, dramatic play and exploratory play. For each interval of 10 s the observers put a cross in the box of the dominant behavior during that period. If the child was not engaged in any of the five play behaviors the behavior was coded as non-play behavior. For the youngest, sensorimotor play was classified as functional play, and sensopathic play as exploratory play. Because there were relatively few observations in the categories of constructive, dramatic and exploratory play, these categories were combined into one category of creative play. The category of games-with-rules also included very few observations in this young age group, and therefore was combined with the category of functional play. For each child, the total percentage of time engaged in functional, creative play and non-play was calculated as the number of intervals in which the behavior was observed, with 0 = 0%, 1 = 17%, 2 = 33%, 3 = 50%, 4 = 67%, 5 = 83% and 6 = 100%. With the total amount adding up to 100%.

Social Behavior. For each of the six 10-second intervals, the observers also checked whether the child was playing or spending time alone or with others (parallel or in a group). Time engaged in social behavior was calculated as the number of intervals in which the behavior was observed, with 0 = 0%, 1 = 17%, 2 = 33%, 3 = 50%, 4 = 67%, 5 = 83% and 6 = 100%.

2.5. Procedure

A set of materials including information brochures, parental consent forms, a protocol for location visits, and forms for observations of children and sites was developed by the research team in collaboration with members of the project's advisory board and professionals with hands-on experience with research at daycare centers. The protocol and materials were tested for practical feasibility at two pilot daycare centers.

After the pilot phase, intervention and control daycare centers were visited by two (out of three) trained observers who were blind to the control or intervention status of the center. All visits started early in the morning, after all children had arrived at the center. Upon arriving, a staff member handed the signed parental consent forms and a list with initials of participating children to the observers. Outdoor observations started as soon as children had free play time outdoors, depending on the day schedule of the organization. With the help of staff members children who were eligible for participation were identified and individually observed for two minutes. Hair-cutting for the cortisol analysis took place during a quiet moment, usually when children were sitting at a table indoors for lunch or a snack. To make the procedure less stressful for the children, cutting was done in a playful manner, with one of the observers presenting herself as a hairdresser and asking whether the child would want a special hair treatment. Hair samples of approximately 100 strands were cut from the back of the child's head using small surgical scissors, as close to the scalp as possible. Hair locks were then taped to a piece of paper with the scalp end marked and stored in an envelope at room temperature until further analyses. At the end of the day, the observers filled in a form with questions about the characteristics of the center, including the quality checklist.

Additional information on the background characteristics of the children and characteristics of the locations was obtained through an online survey that was filled in by a staff member of the organization familiar with the children. Due to low response, data on children's background characteristics (except for gender and age, which were registered during the visits) were incomplete and will not be used in this paper.

2.6. Data analysis

The data follow a hierarchical structure, with children nested in daycare centers. Preliminary multilevel analyses using the general mixed model procedure in SPSS showed that, in the empty model, there was no significant variance at the daycare center level for all dependent variables (ICCs <. 03 for hair cortisol, wellbeing and involvement, and <.08 for physical activity and play and social behavior). These outcomes, together with the relatively small number of 13 daycare centers, indicate that multilevel analysis (which takes into account the clustering of the data) is not required. We therefore conducted all analyses at the individual level. Differences between control and intervention locations were analyzed using ANCOVA, with gender and age group as covariates, and with separate two-way ANCOVAs to test for moderating effects of gender (with age as covariate) and age (with gender as covariate). Size of the location (small, medium, large) was also included as a covariate

the best approximate of the objectively measured location characteristics which were strongly correlated. In a final series of analyses we also tested for moderating effects of location characteristics, with age and gender as covariates.

Functional, creative and non-play behavior (which add up to 100%) were analyzed with multivariate tests. Hair cortisol was analyzed with repeated measures for log transformed four one-month segments. Results are presented as raw data, with test statistics controlled for covariates. In addition to reporting *p*-values, effect sizes were calculated to quantify the magnitude of observed effects. Specifically, partial eta squared (η_p^2) was used to estimate the proportion of variance in the dependent variable explained by the independent variable(s), with effect sizes of around 0.01 indicating a low effect size, around 0.06 indicating a medium effect size, and around 0.14 or higher indicating a high effect size. Percentages of children with high or very high scores in different subgroups are calculated using crosstabs for easy and meaningful interpretation of the findings.

3. Results

Table 4 provides an overview of the mean values for each outcome variable with numbers of children with complete data. In the following sections we will discuss for each variable the differences between control and intervention locations, with graphical illustrations of moderating effects of gender, age and quality of the outdoor area. Tables B1-B3 in Appendix B provides a detailed overview of mean scores and test statistics in control and intervention conditions.

3.1. Hair cortisol

Repeated measures ANCOVA of children's log-transformed hair cortisol concentrations in the past four months, controlled for gender, age and size of locations, shows no significant differences in stress levels between control and intervention locations, neither as a main effect, nor in interaction with time, *ps* > .18. There is, however, a near-significant two-way interaction between intervention and gender for the mean cortisol concentrations, $F(1,57) = 3.86$, $p = .05$, $\eta_p^2 = .06$. As illustrated in Fig. 2, at control locations boys on average had somewhat higher concentrations of hair cortisol (and thus more stress) than girls. At intervention locations boys had somewhat lower concentrations of hair cortisol (and thus less stress) than girls. Overall, the analyses of hair cortisol suggest a positive impact of the COP program on boys and a negative impact on girls. However, the differences are small and only the contrast between boys and girls in the intervention condition reaches near-significance, $p = .08$, $\eta_p^2 = .11$. There are no significant associations between age and cortisol, neither as a main effect, nor in interaction with the intervention, *ps* > .35.

Table 4
Mean values (standard deviation between brackets) and percentages for all outcome variables, with numbers of children with complete data on each variable.

Outcome variable	*N*	Value
Hair cortisol (Mean/SD)		
1-month back	79	9.37 (18.99)
2-months back	78	13.04 (28.80)
3-months back	70	13.10 (30.56)
4-months back	70	14.61 (35.19)
Wellbeing (Mean/SD)	111	3.36 (0.65)
Involvement (Mean/SD)	111	3.30 (0.93)
Physical activity		
% sedentary	96	23%
% moderate	96	9%
% intensive	96	68%
Play behavior		
% functional play	96	38%
% creative play	96	31%
% non-play	96	31%
Social behavior %	96	28%

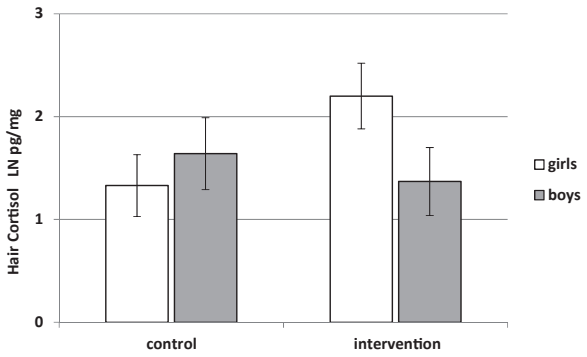

Fig. 2. Mean covariate-adjusted log transformed hair cortisol concentrations in the four-months back segment for girls and boys at control and intervention locations, with 95% CI error bars.

3.2. Wellbeing and involvement

On average, children at intervention locations score about a quarter-point higher on the 5-point wellbeing scale while playing in the outdoor area, $M = 3.54$, $SE = 0.10$, than children at control locations, $M = 3.25$, $SE = 0.80$, a significant difference after controlling for age, gender, and location size, $F(1,106) = 5.67$, $p = .02$, $\eta_p^2 = .05$. At intervention locations, 50% of the children have a score of 4 or 5, indicating high or very high wellbeing, while at control locations only 25% of children have a high or very high score. Boys show higher wellbeing, $M = 3.54$, $SE = 0.08$, than girls, $M = 3.24$, $SE = 0.09$, $F(1,105) = 6.10$, $p = .02$, $\eta_p^2 = .06$. As illustrated in Fig. 3, the difference in wellbeing between control and intervention locations mostly applies to boys, as indicated by a marginally significant interaction effect, $F(1,105) = 3.19$, $p = .08$, $\eta_p^2 = .03$. There are no significant effects of age on wellbeing, neither as a main effect nor in interaction with the intervention, *ps* > .17.

On average, children at intervention locations were observed to be about equally involved during outdoor play, $M = 3.30$, $SE = 0.11$, as children at control locations, $M = 3.32$, $SE = 0.14$. However, differences between intervention and control locations are moderated by gender, $F(1,105) = 7.43$, $p = .008$, $\eta_p^2 = .07$, controlling for age and size of the location. As illustrated in Fig. 4, boys at intervention locations show more involvement than boys at control locations, while girls at intervention location show somewhat less involvement than girls at control locations. There are no significant effects of age on involvement, neither as a main effect nor in interaction with the intervention, *ps* > .40.

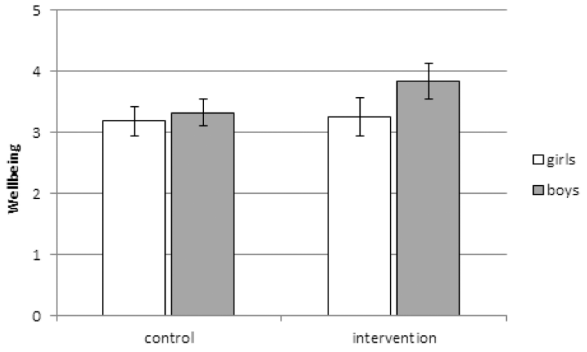

Fig. 3. Mean covariate adjusted wellbeing scores (scale 1–5) of girls and boys at control and intervention locations, with 95% CI error bars.

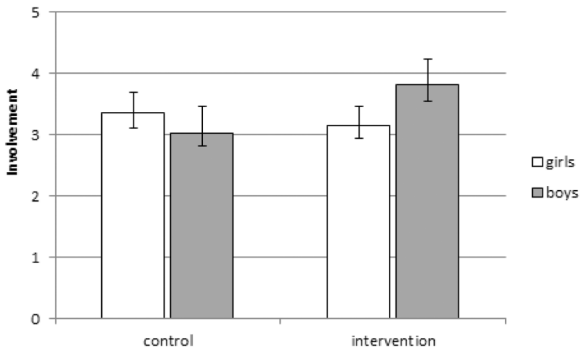

Fig. 4. Mean covariate adjusted involvement scores (scale 1–5) of girls and boys at control and intervention locations, with 95% CI error bars.

3.3. Physical activity

On average, children are very active outdoors, only 23% of the children are mostly sedentary during the one-minute observation period, 9% are moderately physically active, and 68% are highly physically active. There are no main effects of intervention and gender, *ps* > .13, but after controlling for covariates, there is a marginally significant interaction between intervention and gender, F (1,90) = 2.88, p = .09, η_p^2 = .03. As illustrated in Fig. 5, at control locations, 66.7% of girls and 64.9% of boys are highly active. At intervention locations, 57.1% of girls and 86.7% of boys are highly active. Physical activity increases with age, independent of gender, F (1,93) = 12.35, p = .001, η_p^2 = .12. Of the children in the youngest group of up to 1.5 years, 33.3% are highly active, of the children of 1.5–3 years old 67.3% are highly active, of the children in the oldest group of 3–4 years 88.5% are highly active. Effects of the intervention on physical activity are not moderated by age, p > .85.

3.4. Social behavior

Social behavior varies with age, with children in the oldest group engaging in social behavior almost half (49%) of the observed time, against 17% social behavior in the youngest group, and 23% in the group of 1.5–3 years old. These differences remain significant after controlling for age, F (2,89) = 5.14, p = .008, η_p^2 = .10. Social behavior does not differ between boys and girls, p > .36. There are also no differences in social behavior between intervention and control locations, neither as a main effect, nor in interaction with age or gender, *ps* > .42.

3.5. Play behavior

Averaged across all locations, children engage about evenly in functional play (38%), creative play (31%) and non-play (31%) during the one-minute observation period in the outdoor play area. Distributions of play behavior, as indicated by multivariate covariate-adjusted tests, do not differ between intervention and control locations, p>.43. However, differences in play behavior between intervention and control locations are moderated by gender, F (2,89) = 3.13, p = .049, η_p^2 = .07. As illustrated in Fig. 6, boys in the intervention group engage in more creative play and less non-play than boys in the control group, while girls in the intervention group engage in more functional play and less creative play than girls in the control group.

Differences in play behavior between intervention and control locations are also moderated by age, F (4,176) = 3.51, p = .009, η_p^2 = .07. As shown in Fig. 7, the youngest children in the intervention group engage in more functional play than children of similar age in the control group, while the oldest children in the intervention group engage in more creative play than children of similar age in the control group. For the middle group of 1.5 - 3 year-olds there are no significant differences in play behavior between the intervention and control group.

3.6. Quality of the outdoor area

Exploratory analyses of possible influences of location characteristics yielded a significant interaction between intervention and quality of the outdoor area (median split) for functional play, F (1,90) = 7.21, p = .009, η_p^2 = .07, and non-play behavior, F (1,90) = 5.92, p = .017, η_p^2 = .06. In general, as shown in Fig. 8, the intervention resulted in a shift towards more functional play and less non-play at locations with a high-quality outdoor area, while it resulted in a shift towards less functional play and more non-play at locations with a low-quality outdoor area. Quality of the outdoor area did not influence any of the other outcome variables, neither as a main effect nor in interaction with the intervention, *ps* > .33.

4. Discussion

This study examined stress, wellbeing, involvement and play behavior of very young children at nature-based daycare centers. At six centers, staff had participated in a one-year collaborative action COP program together with experts and researchers; seven other centers served as a non-intervention control group. The COP program aimed at strengthening caregivers' pedagogical skills in the outdoor area, with a special focus on vulnerable groups for whom daycare can be a more stressful experience.

The results of post-measurements of hair cortisol and observations of children during free play in the outdoor natural area indicate positive impacts of the COP program for boys, the youngest children, and the oldest children. Compared to boys at control locations, boys at intervention locations showed less stress during the program, and more wellbeing, involvement, physical activity and creative play behavior after the program. Children in the youngest group of up to 1.5 years old showed more functional play in the outdoor area, and less non-play, than children at control locations. In the oldest group of 3-year-olds,

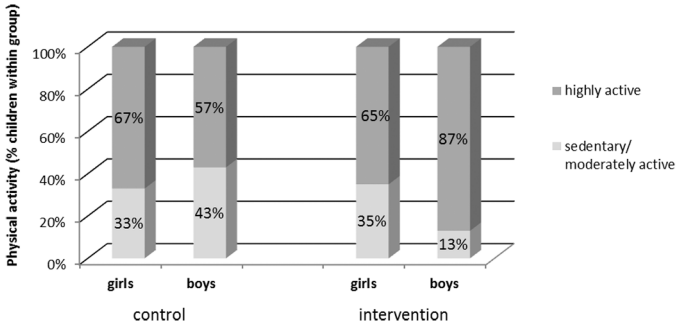

Fig. 5. Mean percentages of girls and boys engaging in highly active and sedentary/moderately active physical activity during 1-minute observations at control and intervention locations.

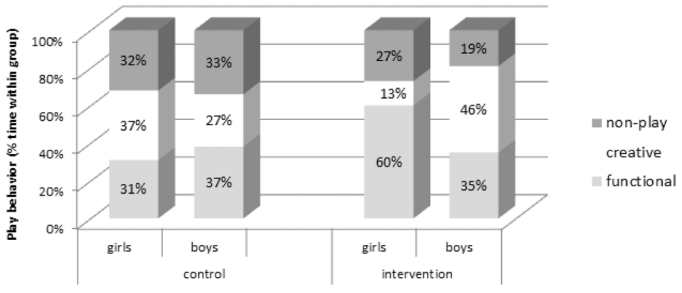

Fig. 6. Mean covariate adjusted percentages of functional, creative and non-play behavior during one-minute observations of boys and girls at control intervention locations.

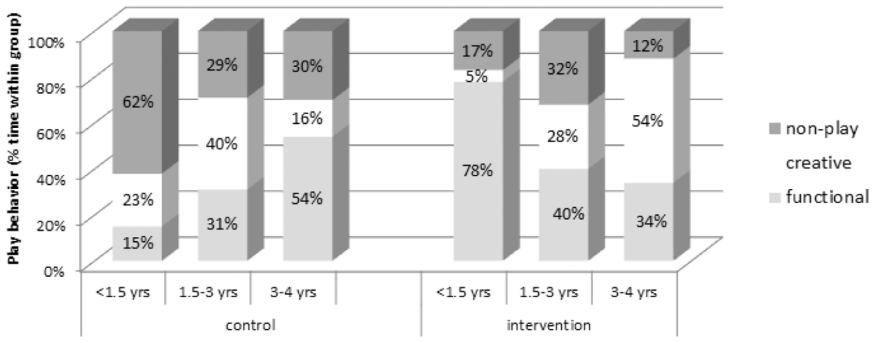

Fig. 7. Percentages of functional, creative and non-play behavior during one-minute observations of children in the three age groups at control and intervention locations.

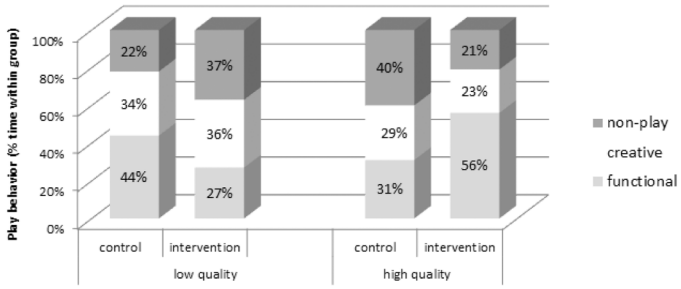

Fig. 8. Percentages of observed functional, creative and non-play behavior at intervention and control locations with a low and a high quality of the outdoor area.

children at intervention locations showed more creative play. For girls the COP program seems less advantageous, with girls at intervention locations showing somewhat more stress than girls at control locations, and less involvement, less physical activity, and less creative play.

These findings may be explained by a shift from a more intervening role of professionals to a more attentively present, mindful role. Such a shift may be especially beneficial for boys and older children, allowing them to engage in more challenging and risky play afforded by the natural environment. Very young children, who often are overprotected, may also benefit from a more non-intervening pedagogical style that allows them to explore the area more freely. However, the causal role of the intervention in the differences between intervention and control locations cannot be established, it is possible that differences observed between the intervention and control group were present at the start of the research and not related to the intervention.

Natural playgrounds have been shown to offer 'inclusive playgrounds', that hold numerous affordances that are well-accommodated to the interests, abilities and needs of both girls and boys (Coen et al., 2019; Dyment and Bell, 2008). The observations at control locations with a natural playground in the present research are in line with this idea of natural playgrounds as inclusive playgrounds, with few differences between boys and girls. The research program possibly shifted this balance, towards boys showing more wellbeing, involvement, physical activity and creative play behavior in the natural playground than girls. From the perspective of inclusiveness of outdoor play, it may thus be questioned whether the program resulted in positive change. Nevertheless, from the broader perspective of inclusiveness of daycare, the shift in balance towards more benefits of nature play for boys may pose a welcome buffer against stress-related problem behavior which is more common in boys than in girls (Tout et al., 1998; Vermeer and van IJzendoorn, 2006).

The program stimulated more creative types of dramatic, constructive and exploratory play behavior in the oldest age group. Creative play is highly valued for its contribution to the healthy development of emotional, cognitive and social skills (Burriss and Tsao, 2002; Wilson, 2007). In the youngest age group, the intervention stimulated more functional play. In the literature on children and nature, functional play is often considered inferior to more creative types of play. However, for toddlers, who are not capable of creative play, functional play is similar to creative play - a wooden stick is magical, not because it can be reimagined as a telescope or a magic wand, but because it is a stick. It can be pushed through a hole, rolled across the floor or dropped repeatedly from the top of a hill. This type of 'cause-and-effect', or sensorimotor play is key for children to make sense of the world. Thus, observations of play behavior are consistent with a positive impact of the COP program on play behavior of both the oldest and the youngest age groups.

4.1. *Strengths and limitations*

Our research complements the existing body of research on benefits of nature for young children by taking a quantitative approach, with a large sample and objective measures and control groups. This stands in contrast with other studies in the field which have typically used a qualitative approach, with small samples, and measures that are open to subjective interpretations. Our research is also among the very few studies that collected samples of children's hair cortisol as a physical measure of stress that has thus far been only scarcely used in research on the benefits of nature for children. Another strength of the present research is that we examined the impact of caregivers' pedagogical skills in use of the outdoor natural area on children's well-being, instead of just looking at the impacts of the physical characteristics of the natural area. This resonates with insights showing that children need to actively engage with nature in an autonomous manner to build a deeper connection with nature that supports their well-being throughout the lifespan and inspires them to take responsibility to care for nature and the planet (Chawla, 2020; Richardson et al., 2021).

Although the research focused on strengthening the pedagogical use, findings indicate that pedagogical use and quality of the natural area may be interdependent. At intervention locations with a relatively low quality, children displayed more non-play behavior, and less functional play, than children at control locations of similar quality. In interpreting this finding, it must be kept in mind that the COP program was aimed at stimulating a passive yet attentive presence of staff which allows children to play freely and wander around in the area on their own. Such a pedagogical approach would only result in more play behavior when the area contains sufficient affordances, loose parts and other elements that invite children to play. If this requirement is not met, children will engage in more non-unoccupied and onlooker behavior, for lack of other play opportunities. This may not necessarily be a bad thing, because children also enjoy being alone and unoccupied, without any peer pressure to engage in play. Indeed, the quality of the outdoor environment did not directly affect children's stress and emotional wellbeing. Nevertheless, these findings suggest that the quality of the natural area

should be taken into account when designing programs for stimulating the pedagogical use of the area (Verstrate and Karsten, 2015).

This study is not without limitations. A first major limitation concerns the fact that, as a result of Corona restrictions, control and intervention locations were not well-matched in terms of size, urbanity, number of children and other characteristics. The research also used a post design only, without measurements at control and intervention locations at baseline before the program. Although we controlled statistically for differences in size (which is also a proxy of urbanity), it cannot be excluded that the differences between control and interventions were caused by variables unrelated to the program. However, the finding that the effects of the program were moderated by gender and age in a way that is consistent with attentive presence as a caregivers' skill that is especially effective in optimizing benefits of outdoor experiences for vulnerable groups, lends support to a causal interpretation of the findings.

Second, within the context of this field research we had to make many compromises between ideal study design and what is practically feasible. For example, although it was initially envisioned that the two observers would make independent observations, it turned out that it was more helpful to find common ground by discussing and resolving differences on spot. As a result, it was not possible to calculate inter-observer reliabilities. Furthermore, it was not possible to schedule all visits to the centers at the same post-intervention period after the last COP meeting. It is thus possible that at some centers which had completed the COP program longer ago the effects of the intervention had already waned, compared to the centers that had just recently completed the program.

Third, the sample was too small to test for three-way interactions between intervention, gender and age, which leaves the possibility that some of the effects of age only apply to boys or girls, or that some of the effects of gender only apply to certain age group. Last, data restriction was restricted to one day at each daycare center. This makes observations sensitive to the influence of weather conditions, novelty effects of being observed or having one's hair being cut, or any other extraordinary events. However, visits took place in approximately the same season (late autumn, early winter) at each center, and special events were avoided.

4.2. Suggestions for future research

As a first recommendation, future research could collect additional parental assessments of their child's well-being and connectedness to nature (Sobko et al., 2018). While we attempted to engage parents through daycare centers, we received a notably low response to our parental survey. Exploring more direct approaches to reach out to parents could potentially yield more comprehensive and detailed insights.

We also encountered challenges in scheduling research team visits with control locations that were not participating in the Community of Practice (COP). Therefore, as a second recommendation, future research may consider making participation in the study more appealing for control locations by implementing a waiting list design. However, such waiting list control conditions are also imbued with many issues, including ethical concerns about delaying the intervention for the control group, especially if it is perceived as beneficial. Additionally, issues related to attrition, with participants in the waiting list group dropping out before the study's conclusion, and external events or life changes during the waiting period that may influence outcomes, can make it difficult to attribute changes solely to the intervention (Elliott and Brown, 2002).

Thirdly, future research could employ a pre-post design to track the progress of individual children over time. However, implementing such a design becomes challenging when dealing with a one-year intervention in the 0–3 age group. Children in this age range exhibit incredibly rapid rates of growth and development over the course of a year (Gardner and Shaw, 2008). Generally, the biologically-driven developmental changes in this age group are so pronounced that discerning the effects of any external factors assessed over a one-year period becomes exceedingly difficult. Additionally, there exists a very real risk that children will drop out of the study before follow-up due to changes in child care centers or their absence during follow-up assessments. In general, utilizing pre-measurements seems more appropriate for shorter interventions lasting only a few weeks or months.

4.3. Conclusion and implications

The current research emphasizes the significance of incorporating pedagogical strategies for the effective use of outdoor natural spaces within daycare centers, as a critical factor in promoting and nurturing a connection between very young children and the natural world. Simultaneously, it underscores the challenge of designing pedagogical programs that accommodate a diverse range of children's needs and abilities. To achieve optimal outcomes, we recommend that researchers and daycare centers collaboratively develop inclusive strategies that engage and benefit all children.

Declarations

This research was funded by the Netherlands Organization for Scientific Research [grant no. 50–54400-98–016]. The Scientific and Ethical Review Board of the Faculty of Behavior & Movement Sciences, VU University Amsterdam, declared that the research proposal complies with the ethical guidelines of the faculty [file VCWE-2019–129R1]. Parents consented to the participation of their child (ren) and the collection of hair cortisol sample by signing an informed consent form.

CRediT authorship contribution statement

Agnes E. van den Berg: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Dieuwke Hovinga:** Conceptualization, Funding acquisition, Project administration, Supervision. **Marian Joven:** Conceptualization, Investigation, Methodology. **Rosanne Steensma:** Conceptualization, Data curation, Investigation, Project administration. **Jolanda Maas:** Funding acquisition, Investigation, Project administration, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Measures

Table A1
Descriptions of levels of wellbeing and involving according to the ZIKO observation instrument (Laevers et al., 2005).

Level	Wellbeing	Involvement
1. Very low	The child shows clear signs of distress, like crying or angry behavior	The child has an absent, passive attitude and shows no signs of concentration, targeted activity, or exploration and interest
2. Low	The posture, facial expression and actions indicate that the child is not feeling well. However, the signals are less pronounced than at level 1 or the discomfort is not expressed all the time	The child shows some activity and concentration but is easily distracted and actions only lead to limited results
3. Moderate	The child gives an 'unmoved' impression, it has a neutral attitude. There are no signs of sadness or pleasure	There is activity all the time, but the child shows no real commitment, is not very concentrated and is not absorbed what it does
4. High	The child shows signs of satisfaction and pleasure. However, the signals of feeling good (see level 5) are not all the time with a large intensity present	There are clear signs of involvement (see level 5), but they are not always fully present
5. Very high	Throughout the observation time, there are clear signals that the child is happy and enjoying him or herself. These signals may include laughter, shouting with pleasures, humming or singing, being energetic, radiating self-confidence	The child is continuously busy all the time and is immersed in its activities. The child is highly motivated, cannot be distracted, pays attention to details, uses all capacities, gains profound new experiences

Table A2
12-item version of the checklist for the quality of the outdoor area at nature-based daycare centers by branch organization Green Cement (translated from Dutch).

1. Is suitable for exploring (all senses are addressed)
2. Allows everyday activities (outside eating and sleeping) to be carried out
3. There are opportunities for sensorimotor play: playful movement, such as looking at one's own hands, listening to birds, waving and kicking, crawling, running and sneaking, reaching and grasping, climbing and clambering
4. There are possibilities for sensory play: playful sensory experience of unformed material
5. There are opportunities for exploratory play: playfully investigating the properties of materials
6. There are opportunities for constructive play, such as stacking blocks, building with branches
7. There are opportunities for pretend play: imitate the actions of adults through play, such as cooking, sweeping, cleaning
8. There are opportunities for fantasy and role play: Playfully creating your own story, such as using a tree trunk as a train, the sandbox as a house
9. Children can climb, clamber and play on different surfaces (including uneven surfaces)
10. There are places for children to hide
11. Contains loose natural materials
12. There are facilities to attract birds, insects and small mammals

Appendix B. Tables with means and test statistics

Table B1
Unadjusted and adjusted means/ percentages ± SE, during 1-minute observations of children, with 95% confidence intervals for differences between control and intervention locations.

Measure	Control	Intervention	95% CI of difference
Hair cortisol (LN pg/mg)			
M	1.55 ± 0.20	1.66 ± 0.22	[− 0.48, 0.70]
M_{adj}	1.45 ± 0.25	1.77 ± 0.27	[− 0.53, 1.19]
Wellbeing (1-5)			
M	**3.25 ± 0.08**	**3.54 ± 0.10**	[0.04, 0.53]
M_{adj}	**3.21 ± 0.09**	**3.60 ± 0.12**	[0.07, 0.72]
Involvement (1-5)			
M	3.30 ± 0.11	3.32 ± 0.14	[− 0.34, 0.38]
M_{adj}	3.17 ± 0.13	3.52 ± 0.17	[− 0.13, 0.83]
Physical activity (1-3)			
M	2.42 ± 0.10	2.52 ± 0.16	[− 0.28, 0.47]
M_{adj}	2.35 ± 0.11	2.68 ± 0.18	[− 0.11, 0.78]
% Social behavior			
M	27.3 ± 4.7	32.7 ± 7.5	[− 6.3, 35.7]
M_{adj}	24.7 ± 4.8	39.4 ± 8.5	[− 12.2, 23.0]
% Functional Play			
M	36.4 ± 4.7	42.3 ± 7.6	[− 11.8, 23.7]
M_{adj}	34.3 ± 5.1	47.4 ± 9.0	[− 9.0, 35.2]
% Creative Play			
M	31.5 ± 4.5	29.0 ± 7.3	[− 19.5, 14.5]
M_{adj}	31.4 ± 5.0	29.4 ± 8.7	[− 23.6, 19.5]
% Non-play			
M	32.1 ± 4.5	28.7 ± 7.1	[− 20.1, 13.2]
M_{adj}	34.3 ± 4.7	23.2 ± 8.3	[− 31.7, 9.5]

Note: adjusted means are controlled for age, gender and size of location; values in bold differ significantly between control and intervention groups at $p < .05$.

Table B2
Adjusted estimated marginal means and percentages ± SE for boys and girls at intervention and control locations.

Measure	Control	Intervention
Hair cortisol (pg/mg)		
Girls	1.33 ± 0.30	2.20 ± 0.35[a]
Boys	1.64 ± 0.32	1.37 ± 0.33[b]
Wellbeing (1-5)		
Girls	3.17 ± 0.12	3.32 ± 0.16[a]
Boys	3.26 ± 0.11	3.83 ± 0.15[b]
Involvement (1-5)		
Girls	3.35 ± 0.17	3.16 ± 0.23[a]
Boys	**3.03 ± 0.15**	**3.81 ± 0.21[b]**
Physical activity (1-3)		
Girls	2.36 ± 0.16	2.32 ± 0.24
Boys	**2.32 ± 0.14**	**3.05 ± 0.24**
% Social behavior		
Girls	28.9 ± 7.0	40.2 ± 11.0
Boys	38.9 ± 6.3	39.9 ± 11.5
% Functional Play		
Girls	**31.2 ± 7.3**	**60.1 ± 11.4**
Boys	36.7 ± 6.5	34.8 ± 11.9
% Creative Play		
Girls	**36.6 ± 7.0**	**12.7 ± 10.9[a]**
Boys	27.3 ± 6.2	46.0 ± 11.4[b]
% Non-play		
Girls	32.2 ± 6.9	27.1 ± 10.8
Boys	36.0 ± 6.2	19.2 ± 11.3

Note: values are adjusted for age and size of location; values in bold differ significantly between intervention and control locations within groups of boys and girls at $p < .05$; values with unequal superscripts differ significantly between girls and boys within play category and experimental groups at $p < .05$.

Table B3
Covariate-adjusted percentages of play behavior ± SE at intervention and control locations as a function of age and quality of the outdoor area.

Measure	Control	Intervention
Age[1]		
% Functional Play		
≤ 1.5 yrs	**14.5 (12.0)[a]**	**77.8 (17.5)**
1.5-3 yrs	31.2 (6.2)[ab]	40.0 (10.9)
3 yrs	54.1 (9.1)[b]	34.4 (15.1)
% Creative Play		
≤ 1.5 yrs	22.8 (11.7)	5.3 (17.0)
1.5-3 yrs	40.1 (6.0)	28.4 (10.5)
3 yrs	**15.6 (8.9)**	**53.7 (14.7)**
% Non-play		
≤ 1.5 yrs	62.7 (11.5)[a]	16.9 (16.8)
1.5-3 yrs	28.7 (5.9)[b]	31.5 (10.4)
3 yrs	30.3 (8.7)[b]	11.8 (14.5)
Quality Outdoor Area[2]		
% Functional Play		
low	44.0 (7.1)	27.6 (10.8)
high	**30.5 (6.2)**	**55.7 (10.4)**
% Creative Play		
low	34.3 (7.0)	35.9 (10.6)
high	29.3 (6.1)	22.8 (10.2)
% Non-play		
low	21.6 (6.7)[a]	36.5 (10.1)
high	40.2 (5.8)[b]	21.5 (9.8)

Note: [1]adjusted for gender and size of location; [2]adjusted for age and gender; values in bold differ significantly per row between intervention and control locations at $p < .05$; values with unequal superscripts differ significantly within play category and experimental groups at $p < .05$.

References

Bowlby, R., 2007. Babies and toddlers in non-parental daycare can avoid stress and anxiety if they develop a lasting secondary attachment bond with one carer who is consistently accessible to them. Attach. Hum. Dev. 9 (4), 307–319.

Brussoni, M., Gibbons, R., Gray, C., Ishikawa, T., Sandseter, E.B.H., Bienenstock, A., Janssen, I., 2015. What is the relationship between risky outdoor play and health in children? A systematic review. Int. J. Environ. Res. Public Health 12 (6), 6423–6454.

Burriss, K.G., Tsao, L.-L., 2002. Rev. Res.: how much do we know Import. Play Child. Dev. ? *Child. Educ.* 78 (4), 230–233.

Chawla, L., 2020. Childhood nature connection and constructive hope: A review of research on connecting with nature and coping with environmental loss. People Nat. 2 (3), 619–642.

Coen, S.E., Mitchell, C.A., Tillmann, S., Gilliland, J.A., 2019. 'I like the "outernet" stuff': girls' perspectives on physical activity and their environments. Qual. Res. Sport, Exerc. Health 1–19.

Cooper, A., 2015. Nature and the outdoor learning environment: the forgotten resource in early childhood education. Int. J. Early Child. Environ. Educ. 3 (1), 85–97.

Dankiw, K.A., Tsiros, M.D., Baldock, K.L., Kumar, S., 2020. The impacts of unstructured nature play on health in early childhood development: A systematic review. PLoS ONE 15 (2), e0229006.

De Schipper, J.C., Tavecchio, L.W., Van IJzendoorn, M.H., Van Zeijl, J., 2004. Goodness-of-fit in center day care: relations of temperament, stability, and quality of care with the child's adjustment. Early Child. Res. Q. 19 (2), 257–272.

Dyment, J.E., Bell, A.C., 2008. Our garden is colour blind, inclusive and warm': reflections on green school grounds and social inclusion. Int. J. Incl. Educ. 12 (2), 169–183. https://doi.org/10.1080/13603110600855671.

Elliott, S., Brown, J., 2002. What are we doing to waiting list controls? Behav. Res. Ther. 40 (9), 1047–1052.

Fyfe-Johnson, A.L., Marcuse, E.K., Tandon, P., Hazlehurst, M., Bratman, G.N., Thomas, R., Garrett, K., 2021. Nature contact and children's health: a systematic review. American Academy of Pediatrics,.

Gardner, F., Shaw, D.S., 2008. Behavioral problems of infancy and preschool children (0–5). Rutter's Child and Adolescent Psychiatry, pp. 882–893.

Groeneveld, M.G., Vermeer, H.J., Linting, M., Noppe, G., van Rossum, E.F., van IJzendoorn, M.H., 2013. Children's hair cortisol as a biomarker of stress at school entry. Stress 16 (6), 711–715.

Hargreaves, A., & Fullan, M. (2015). *Professional capital: Transforming teaching in every school*: Teachers College Press.

Harwood, D., Reichheld, S., McElhone, S., McKinlay, B., 2017. "I can climb the tree!" Exploring Young Children's Play and Physical Activity in a Forest School Program. Int. J. Holist. Early Learn. Dev. 4, 45–62.

Johnstone, A., McCrorie, P., Thomson, H., Wells, V., & Martin, A. (2021). *Nature-based early learning and childcare: Influence on children's health, wellbeing and development. Literature review*. Edinburgh: Scottish Government.

Joven, M., & Hovinga, D. (2017). *Van weten naar doen: samen versterken pedagogisch medewerkers en IVN-medewerkers het pedagogisch gebruik van de buitenruimte in de kinderdagopvang [From knowing to doing: strengthening the pedagogical use of the outdoor area at daycare centers together with pedagorical staff and nature educators]*. Leiden: Hogeschool Leiden. ⟨https://www.hsleiden.nl/binaries/content/assets/hsl/lectoraten/natuur-en-ontwikkeling-kind/eindrapportage-van-weten-naar-doen.pdf⟩.

Helmerhorst, K.O., Riksen-Walraven, J.M., Vermeer, H.J., Fukkink, R.G., Tavecchio, L. W., 2014. Measuring the interactive skills of caregivers in child care centers: Development and validation of the caregiver interaction profile scales. Early Educ. Dev. 25 (5), 770–790.

Kahn, I., Kellert, P.H., 2002. Children and nature: psychological, sociocultural and evolutionary investigations. MIT press, Cambridge, MA.

Keenan, K., Shaw, D., 1997. Developmental and social influences on young girls' early problem behavior. Psychol. Bull. 121 (1), 95.

Kirschbaum, C., Tietze, A., Skoluda, N., Dettenborn, L., 2009. Hair as a retrospective calendar of cortisol production—increased cortisol incorporation into hair in the third trimester of pregnancy. Psychoneuroendocrinology 34 (1), 32–37.

Klaver, K., Baart, A., 2011. Attentiveness in care: towards a theoretical framework. Nurs. Ethics 18 (5), 686–693.

Laevers, F. , Daems, M. , De Bruyckere, G. , Declercq, B. , Silkens, K. , Snoeck, G. , Van Kessel , M. (2005). ZiKo: Zelfevaluatie-instrument voor welbevinden en betrokkenheid van kinderen in de opvang (SICs: A process-oriented self-evaluation instrument for wellbeing and involvement of children in care settings). Leuven: Expertisecentrum ervaringsgericht onderwijs, Katholieke Universiteit Leuven. ⟨https://docplayer.net/21009928-Sics-ziko-well-being-and-involvement-in-care-a-process-oriented-self-evaluation-instrument-for-care-settings.html⟩.

Leather, M., 2018. A critique of "Forest School" or something lost in translation. J. Outdoor Environ. Educ. 21 (1), 5–18.

Mertler, C.A. (2019). The Wiley handbook of action research in education: John Wiley & Sons.

Moore, R.C., & Cooper-Marcus, C. (2008). Healthy planet, healthy children: Designing nature into the daily spaces of childhood. In S.R. Kellert, J.H. Heerwagen & M.L. Mador (Eds.), *Biophilic design: The theory, science, and practice of bringing buildings to life* (pp. 153–205): Wiley.

Mygind, L., Kurtzhals, M., Nowell, C., Melby, P.S., Stevenson, M.P., Nieuwenhuijsen, M., Enticott, P.G., 2021. Landscapes of becoming social: A systematic review of evidence for associations and pathways between interactions with nature and socioemotional development in children. Environ. Int. 146, 106238.

Nisbet, E.K., Zelenski, J.M., 2011. Underestimating nearby nature: Affective forecasting errors obscure the happy path to sustainability. Psychol. Sci. 22 (9), 1101–1106. https://doi.org/10.1177/0956797611418527.

Pensini, P., Horn, E., Caltabiano, N.J., 2016. An exploration of the relationships between adults' childhood and current nature exposure and their mental well-being. Child., Youth Environ. 26 (1), 125–147.

Puhakka, R., Rantala, O., Roslund, M.I., Rajaniemi, J., Laitinen, O.H., Sinkkonen, A., Group, A.R., 2019. Greening of daycare yards with biodiverse materials affords well-being, play and environmental relationships. Int. J. Environ. Res. Public Health 16 (16), 2948.

Putra, I., Astell-Burt, T., Cliff, D.P., Vella, S.A., John, E.E., Feng, X., 2020. The relationship between green space and prosocial behaviour among children and adolescents: a systematic review. Front. Psychol. 11, 859.

Rice, C.S., Torquati, J.C., 2013. Assessing connections between young children's affinity for nature and their experiences in natural outdoor settings in preschools. Child. Youth Environ. 23 (2), 78–102. https://doi.org/10.7721/chilyoutenvi.23.2.0078.

Richardson, M., Hunt, A., Hinds, J., Bragg, R., Fido, D., Petronzi, D., White, M., 2019. A measure of nature connectedness for children and adults: Validation, performance, and insights. Sustainability 11 (12), 3250.

Richardson, M., Passmore, H.-A., Lumber, R., Thomas, R., Hunt, A., 2021. Moments, not minutes: The nature-wellbeing relationship. Int. J. Wellbeing 11, 1.

Rubin, K.H. (2001). The play observation scale (POS). *Unpublished manuscript, University of Maryland*.

Russell, E., Koren, G., Rieder, M., Van Uum, S., 2012. Hair cortisol as a biological marker of chronic stress: current status, future directions and unanswered questions. Psychoneuroendocrinology 37 (5), 589–601.

Sagor, R. (2010). Collaborative action research for professional learning communities: Solution Tree Press.

Sobko, T., Jia, Z., Brown, G., 2018. Measuring connectedness to nature in preschool children in an urban setting and its relation to psychological functioning. PLoS ONE 13 (11), e0207057.

Tillmann, S., Tobin, D., Avison, W., Gilliland, J., 2018. Mental health benefits of interactions with nature in children and teenagers: a systematic review. J. Epidemiol. Community Health 72 (10), 958–966.

Tout, K., De Haan, M., Campbell, E.K., Gunnar, M.R., 1998. Social behavior correlates of cortisol activity in child care: Gender differences and time-of-day effects. Child Dev. 69 (5), 1247–1262.

Ulset, V., Vitaro, F., Brendgen, M., Bekkhus, M., Borge, A.I.H., 2017. Time spent outdoors during preschool: Links with children's cognitive and behavioral development. J. Environ. Psychol. 52, 69–80. https://doi.org/10.1016/j.jenvp.2017.05.007.

Van Polanen, M., Colonnesi, C., Tavecchio, L.W., Blokhuis, S., Fukkink, R.G., 2017. Men and women in childcare: a study of caregiver–child interactions. Eur. Early Child. Educ. Res. J. 25 (3), 412–424.

Vanaken, G.-J., Danckaerts, M., 2018. Impact of green space exposure on children's and adolescents' mental health: A systematic review. Int. J. Environ. Res. Public Health 15 (12), 2668.

Vermeer, H.J., van IJzendoorn, M.H., 2006. Children's elevated cortisol levels at daycare: A review and meta-analysis. Early Child. Res. Q. 21 (3), 390–401.

Verstrate, L., Karsten, L., 2015. Development of nature playgrounds from the 1970s onwards. In: Evans, B., Horton, J., Skelton, T. (Eds.), Play, recreation, health and well being. Geographies of children and young people. Springer, pp. 1–19.

Weeland, J., Moens, M.A., Beute, F., Assink, M., Staaks, J.P.C., Overbeek, G., 2019. A dose of nature: Two three-level meta-analyses of the beneficial effects of exposure to nature on children's self-regulation. J. Environ. Psychol. 65, 101326 https://doi.org/10.1016/j.jenvp.2019.101326.

Wells, N.M., Lekies, K.S., 2006. Nature and the life course: Pathways from childhood nature experiences to adult environmentalism. Child. Youth Environ. 16 (1), 1–24.

Wernersson, I. (2015). Men, masculinities and teaching in early childhood education: Routledge.

Wilson, R. (2007). *Nature and young children: Encouraging creative play and learning in natural environments*: Routledge.