

A comparison of children with ADHD in a natural and built setting

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Abstract

Background A link has been suggested between children's disconnection from nature and the recent surge in childhood disorders such as Attention Deficit Hyperactivity Disorder (ADHD). Research on benefits of nature for healthy children provides some support for such a link. However, only a few studies have directly examined the influence of contact with nature on children with ADHD.

Aim The aim of the present research was to gain more insight into the behaviour and emotional and cognitive functioning of children with ADHD in a natural and built setting.

Methods Two groups of six children (age 9–17) who stayed at care farms for children with ADHD in the Netherlands were systematically observed, questioned, and tested during visits to a wooded area and a small town.

Results Both groups performed better on a concentration task in the woods than in the town, despite the fact that all children visited the town after the woods and thus their scores in the town were possibly inflated by learning effects. However, the behaviour and emotional functioning in the two settings differed between the groups. One group of children liked the woods better than the town and displayed more positive behaviours and feelings in the natural environment. The other group of children liked the town equally well as the woods and displayed positive behaviours and feelings in both settings, although they showed somewhat more non-social, aggressive, inattentive, impulsive and hyperactive behaviour in the town than in the woods.

Conclusions These results suggest that natural areas provide a consistent positive environment for children with ADHD. However, more research is needed to obtain a fuller understanding of the influences of the physical environment on children with ADHD.

Keywords

ADHD, attention deficit disorder, behaviour, benefits, environmental influences, well-being

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Introduction

Videogames, television, indoor play gardens, and even indoor skiing halls; these days, children grow up with a wealth of indoor play facilities to choose from (Karsten 2005). In addition, increasing urbanization has strongly diminished opportunities for safe outdoor play, and many parents actively discourage children from going outdoors to prevent them from

being harmed (Veitch *et al.* 2010). For these and other reasons more and more children are growing up disconnected from nature and the outdoors. According to authoritative opinions, this disconnection from nature may have important consequences for children's healthy development and well-being (Children's Play Information Service 2007; Little & Wyver 2008). In particular, it has been suggested that a lack of contact with nature is one of the main reasons underlying the recent

surge in childhood maladies such as Attention Deficit Hyperactivity Disorder (ADHD). In his book *Last Child in the Woods* Louv (2008) even coined the term 'nature deficit disorder' as an alternative name for this type of disorder.

Arguably, causal claims about an influence of lack of nature may be too strong considering the multiple causes and strong genetic components of ADHD (Canu & Gordon 2005; Daley 2006). However, there are some indications that contact with nature may reduce symptoms of ADHD, which include inattention, hyperactivity, and impulsiveness. Two large-scale surveys among parents of children with ADHD in the USA have shown that parents see a reduction in symptoms in their child after it has played in a natural environment (Faber Taylor *et al.* 2001; Kuo & Faber Taylor 2004). A recent study from this same group among 17 school-age children with ADHD provides some experimental evidence for a positive influence of nature on inattention in children with ADHD (Faber Taylor & Kuo 2009). The children performed better on an attentional task (Digit Span Backwards) after a 20-min individually guided walk in a park than after walks of similar length in downtown or neighbourhood settings.

The idea that contact with nature can reduce symptoms of ADHD receives further support from a broader range of well-controlled studies on beneficial effects of nature for healthy children (see for reviews Kahn & Kellert 2002; Faber Taylor & Kuo 2006; Van Den Berg & De Hek 2009). These studies have shown positive influences of contact with nature in multiple domains. For example, in the emotional domain, it has been found that participation in nature-based programmes can increase self-esteem and emotional well-being, especially in children and youth from poor backgrounds (Readdick & Schaller 2005; Van Der Waal *et al.* 2008). Furthermore, a study among rural school-age children revealed that children with high amounts of nature in and around their homes exhibited higher self-esteem and better resilience against negative impacts of stressful life events (Wells & Evans 2003).

In the cognitive domain, research among school-age children has shown improvements in parental evaluations of inattention and hyperactivity in children from poor neighbourhoods who moved to better quality homes (Wells 2000), better self-discipline in children who live in apartments with views of nature (Faber Taylor *et al.* 2002), and better performance on cognitive tasks when these tasks are carried out in the garden of a school (Mancuso *et al.* 2006). A recent study also showed that children in pre-schools with natural outdoor play areas scored better on a test for cognitive functioning (Mårtensson *et al.* 2009).

In the behavioural domain, correlational studies have consistently shown that children in all age groups display higher

levels of physical activity when they have access to parks and other natural areas (Boldemann *et al.* 2006; Cohen *et al.* 2006; Epstein *et al.* 2006; Roemmich *et al.* 2006). A longitudinal study revealed that playing in nature stimulates physically intensive play and promotes the development of motor skills in pre-school children (Fjørtoft 2004). This suggests that nature can stimulate children to 'live out their energy' and thus reduce their (hyper)activity levels. Furthermore, observational studies have reported less aggressive and more social, creative and exploratory play behaviour in natural as compared with non-natural areas (Faber Taylor *et al.* 1998; Van Den Berg *et al.* 2007b).

Taken together, research among children with ADHD and healthy children indicates that contact with nature may reduce the ADHD symptoms of inattention and hyperactivity/impulsivity as well as related problems such as a depressed mood, low self-esteem, aggressive behaviour, and social problems. This is important because there is an urgent public interest in complementary/alternative treatments for ADHD (Kemper *et al.* 2008). However, much more research is needed in this emerging field. Among other things, there is a need for exploratory observational studies, which can provide insight into how children with ADHD actually behave in natural and other settings.

The present research

The aim of the present research was to gain more insight into the behaviour and cognitive and emotional functioning of children with ADHD in a natural and built setting. To achieve this, we carried out a field study at two farms in the Netherlands that organize weeks and weekends for children with ADHD. The children were observed and tested during visits to a wooded area and a small town. Based on previous research, we expected that children with ADHD would respond more positively to the natural than to the built setting.

Methods

Study location and participants

This study was conducted at the two care farms for children with ADHD of the foundation 'OjeeADHD', located in a rural area in the province of Zeeland, the Netherlands. Both farms are run by a couple who themselves have three sons with ADHD. One farm (named 'Malversweie') is a big farm with a large indoor area, and the other farm (named 'De Stelle') is a smaller farm with various types of livestock. In the remainder of the

	Total (n = 12)	Farm 1 (n = 6)	Farm2 (n = 6)
Age (years)	12.83 ± 2.33	12.67 ± 1.36	13 ± 3.16
Youngest child	9	11	9
Oldest child	17	14	17
Gender (% boys)	83.3%	100%	66.7%
Diagnosis			
ADHD only	33.3%	33.3%	33.3%
ADHD + comorbidity	50%	50%	50%
ADD	8.3%	16.7%	0%
ODD + ADHD	8.3%	0%	16.7%
Medication (% yes)	83.3%	66.7%	100%
Well-being (PedsQL; 1–5)			
Physical	1.1 ± 0.20	1.00 ± 0	1.2 ± 0.25
Emotional	2.35 ± 0.76	2.29 ± 0.68	2.42 ± 0.90
Social	1.89 ± 0.70	1.72 ± 0.64	2.06 ± 0.77
Cognitive	3.00 ± 1.06	3.0 ± 1.33	3.00 ± 0.84
Type of house			
Flat, apartment	8.3%	0%	16.7%
Terraced house	75%	83.3%	66.7%
Semi-detached	16.7%	16.7%	16.7%
Type of garden			
Natural (grass, trees)	0%	0%	0%
Cultivated (flowers, terrace)	75%	66.7%	100%
No garden	16.7%	33.3%	0%
Pet(s) (% yes)	100%	100%	100%
Hobbies			
Animals	33.3%	33.3%	33.3%
Active	41.7%	50.0%	33.3%
Non-active	8.3%	0%	16.7%
Combination	16.7%	16.7%	16.7%
Playing outdoors			
Often	75.0%	83.3%	66.7%
Sometimes	16.7%	0%	33.3%
Never	8.3%	16.7%	0%
Outdoor play setting			
Natural	8.3%	0%	16.7%
Non-natural/urban	83.3%	83.3%	83.3%
Never play outside	8.3%	16.7%	0%
Play indoors or outdoors?			
Outdoors	41.7%	50%	33.3%
Indoors	41.7%	33.3%	50%
No preference	16.7%	16.7%	16.7%
Previous visit to location (% yes)			
Woods	100%	100%	100%
Town	100%	100%	100%

Table 1. Characteristics of the children (means ± standard deviations and percentages)

Note: there were no significant differences between the two groups on any of the variables.

ADD, attention deficit disorder; ADHD, Attention Deficit Hyperactivity Disorder; ODD, Opposition Defiant Disorder.

article, these two farms will be referred to as 'Farm 1' (Malverweie) and 'Farm 2' (De Stelle).

For the purpose of the current research, the owners of the farms organized a midweek in July 2009 for children of 9 years and older. During this midweek, each farm accommodated six children, yielding a total sample of 12 children aged 9–17. The two groups were examined separately using the same procedures for each group. All children were officially diagnosed with ADHD, because only diagnosed children can stay at the Ojee-

ADHD farms. Unfortunately it was not possible for the children to join this research unmedicated; all but two children took medication during the research period. Table 1 provides a detailed overview of the characteristics of the participants.

Design, experimental settings and activities

The study consisted of a field study in which two groups of children with ADHD visited, on consecutive days, a natural and

a built setting. The natural setting was an open spot in a nearby wooded area; the built setting was a square in a quiet neighbourhood in the nearby town of Zierikzee. The built setting was selected to be comparable to the natural setting with respect to spaciousness, quietness and other characteristics. To acquaint the children with the procedure, and to obtain baseline test measures, a trial session was held inside the farms on Monday. On Tuesday, the children visited the woods, and on Wednesday, they visited the town. On each day, one group went to the location in the morning and the other in the afternoon (in varying orders). For logistic reasons it was not possible to randomize the order in which the children visited the natural and built setting. However, the visit to the natural setting was scheduled before the visit to the town to avoid alternative explanations of positive functioning in nature in terms of learning effects or therapeutic influences of staying at the farm.

In each setting, the children first carried out a group activity of light to moderate physical intensity that was appropriate for the setting. At the farm, the children engaged in a Wii competition; in the woods, they built a cabin; and in the town, they went on an expedition across the neighbourhood. During the activities, the experimenter observed the children and made notes. After the activity, the children were asked to sit down for a structured group interview about their experience of the setting and their current mood and feelings. At the end of this interview, the children were individually tested for their cognitive functioning.

Dependent measures and tests

Because most children suffered from a limited attention span and reading problems, all questions were asked aloud in a playful manner. Only a few clear response options per question were provided, to which the children could answer by holding up a coloured panel (red = no; orange = a little; green = yes).

Observations

During the activity, the children were observed using a checklist that made a distinction between six types of (play) behaviour: social behaviour, cooperative behaviour, enthusiasm, aggressive behaviour (verbal and physical), inattention, and impulsivity/hyperactivity. In each setting, the experimenter described the group's behaviour on each dimension in a few keywords.

Environmental evaluation

After the activity, the experimenter asked ten closed-ended questions about the environment, which were adapted from

Table 2. Items in the General Environmental Evaluation scale and the Perceived Restorativeness scale

General Environmental Evaluation	Perceived Restorativeness
1. I think it is beautiful here	6. I am not so quickly distracted here
2. It is exciting here, there is much to explore	7. I can think clearly here
3. I could stay here for a long time without getting bored	8. I feel quiet in my head here
4. I feel at home here	9. I feel free here
5. I love this place!	10. I can forget all my problems and worries here

various existing scales, including the Connectedness to Nature Scale (Mayer & Frantz 2004), and the Perceived Restorativeness Scale (Hartig *et al.* 1997). The questions were divided into two subscales: General Environmental Evaluation and Perceived Restorativeness (cf. Table 2). Children could answer with '1 = no', '2 = a little', '3 = yes'. The reliability of both subscales was sufficient for all measurements with Cronbach's alpha's ranging between .65 and .92.

Mood test

The children were asked to describe their current mood using a simple smiley-test, which was previously developed and used in research among healthy children (Van Den Berg *et al.* 2007b). This test consisted of six pairs of feelings: (1) sad – happy; (2) worried – not worried; (3) tired – energetic; (4) angry – not angry; (5) uncertain – certain; and (6) scared – not scared. Each pair of feeling was illustrated by two smileys, with seven circles in-between. Children were asked to colour the circle that fitted best the way they felt (1 = negative feeling, 7 = positive feeling). The mood test showed good reliability; Cronbach's alpha varied between .84 and .94 for all measurements.

Concentration test

Finally, each child performed an individually guided concentration test, consisting of the 'Opposite Worlds' test from 'the Test of Everyday Attention for Children' (TEA-Ch; Manly *et al.* 1999). This test consists of a winding 'path' of squares with the digits 1 and 2. In the 'Sameworld' condition, children were asked to read out the digits aloud as quickly as possible in the conventional manner. In the 'Oppositeworld' condition they were asked to say the opposite for each digit ('one' for 2 and 'two' for 1) as quickly as possible, inhibiting the prepotent verbal

response. The difference in time between the Sameworld and the Oppositeworld conditions was taken as the dependent variable.

General questionnaire

Background information concerning the ADHD diagnosis and treatment, socio-demographic background, hobbies, play behaviour, environmental preferences, and quality of life of each child were collected by means of a general written questionnaire, which was filled in by the supervisors of the farm together with the experimenter and the child. The questionnaire consisted of closed- and open-ended questions. The answers to the open-ended questions were coded into a limited number of categories (shown in Table 1). To assess whether the child preferred to play outdoors or indoors, 11 forced choice options were presented, which asked the child to choose between an indoor setting or activity and an outdoor setting (e.g. playing in an indoor play hall or playing in nature; staying in a holiday home or camping). For each child, the preference for playing indoors or outdoors was determined based on whether the majority of choices were for outdoor or indoor settings/activities. The questionnaire also included the Pediatric Quality of Life Inventory™ 4.0 (PedsQL, Varni *et al.* 2001). The PedsQL measures quality of life on four dimensions: physical, emotional, social, and cognitive. For each dimension, the child is asked to indicate on a five-point scale ranging from 'never' to 'almost always' how often he/she has problems with different types of activities and tasks.

Procedure

The experimenter stayed at the farms and took part in the activities during the entire midweek. The first (trial) session at the farm was held on Monday afternoon. First, the children of Farm 1 were observed and tested. Then the experimenter went to Farm 2 to conduct the same activities with that group. On Tuesday the children visited the woods, accompanied by the experimenter and a familiar staff member. The group of Farm 1 went in the morning, by car, because the woods were too far to walk from this farm. The group of Farm 2 walked to the woods in the afternoon. On Wednesday, the children visited the town of Zierikzee by car. The children of Farm 2 went in the morning, accompanied by the experimenter and the two owners of the farm. The children of Farm 1 went to town in the afternoon. Unfortunately, because of an unexpected sick call of a staff member, the owners could not accompany the children in the

afternoon. Instead, the experimenter was accompanied by a trainee. The total duration of each session was about 1 h.

Data analysis

This mixed method study relied on a combination of qualitative and quantitative methods of data analysis. Observational data were analysed using a basic interpretive method that was guided by the six behavioural dimensions included in the observational scheme. Quantitative analyses were carried out using SPSS 17.0 for Windows. Repeated measures analyses of variance (ANOVAs) with condition (Woods, Town) as the within subjects factor and group (Farm 1, Farm 2) as the between subjects factors were used to determine differences in environmental evaluations, emotional and cognitive functioning between the natural and built setting. Because of the small sample size, power to detect differences between the conditions was limited. Therefore, we calculated eta squared (η^2) as a measure of effect size that is roughly equal to the proportion of explained variance in the sample (Levine & Hullett 2002). According to Cohen's (1988) rule-of-thumb, an η^2 of .01 is small, .06 is medium, and .14 is large.

Results

Sample characteristics

Table 1 contains the sample characteristics. The two farms differed somewhat in age and gender composition. The big farm (Farm 1) accommodated only boys from 11 to 14 years old. The smaller farm (Farm 2) accommodated four boys and two girls from 9 to 17 years old. Although these differences were not significant, the absence or presence of girls and younger or older children clearly influenced the atmosphere and dynamics in each group.

Eleven out of 12 children were diagnosed with the combined subtype of ADHD, and one child was diagnosed with the predominantly inattentive subtype (attention deficit disorder). More than half of the children suffered from comorbid disorders, such as Opposition Defiant Disorder (ODD) or autism. One child (at Farm 2) had ODD as the main diagnosis and ADHD as comorbid disorder. All but two children (from Farm 1) took medication for their disorder. Results of the quality of life-questionnaire (PedsQL) show that all children scored low on physical problems and relatively high on emotional, cognitive and social problems. As expected, the most serious problems occurred in the cognitive domain.

Most children lived in small apartments or terraced houses with little outdoor space. All but two children had a garden at home, but there were little opportunities to play in those gardens. Despite the fact that they lived in small houses, all children had one or more pets, and the hobbies of about one-third of the children also involved pets. Most children engaged in outdoor play, and most of them did so frequently. When playing outside, most children went to a non-natural setting, like the city or the school yard. Only one child went to a natural setting sometimes. Despite the fact that most children played outside frequently, they did not display a clear preference for playing outdoors. All children had visited the woods and the town before. There were no significant differences between the two groups on any of the variables in Table 1.

Observations

Farm 1

In the woods, the children of Farm 1 showed positive behaviours. Beforehand they protested somewhat, but upon arrival at the location they started to talk and socialize. During the cabin building activity they helped each other and were concentrated on the activity. When the activity was finished, they all came together and answered the questions without complaining. They even showed competitive behaviour at the concentration test; they wanted to beat each other as well as to improve their scores of the day before. With respect to the items on the observation list, the children showed much enthusiasm and social and cooperative behaviour, and did not display aggressive, inattentive, or impulsive/hyperactive behaviour.

During the activity in town the next day the children of Farm 1 displayed quite different behaviours. From the start of the day the children complained about having to go to town. At the location most of them did not listen to the instructions. During the expedition across the town, they walked slowly and did not try to answer the questions. Some of them yelled at passers-by and crossed the streets without looking. One of the boys showed much aggressive and angry behaviour and walked away a couple of times. After the activity had ended they did not want to listen until they were promised an ice cream and even then it was hard to get them to answer all the questions. In general, the children displayed a lack of social, cooperative, and enthusiastic behaviour, much (verbal) aggressive behaviour, no attention to the game, and much impulsive/hyperactive behaviour. Even after returning to the farm, the children showed aggressive behaviour against each other and the staff.

Farm 2

The children of Farm 2 generally seemed to enjoy going to the woods and during the activity they helped each other, showing inventiveness by choosing all strange kinds of materials to build a cabin. They all wanted to build the nicest cabin. No aggressive or impulsive behaviour was observed. Except for the two girls, who were afraid of the spiders, etc. that were hidden in the natural materials, everyone was active and attentive to the activity. When the activity was over, they did not object to coming together and they even took pleasure in answering the questions. With respect to the items on the observation checklist, they showed much enthusiasm and social and cooperative behaviour, and did not display aggressive, inattentive, or impulsive/hyperactive behaviour.

The observations of the children of Farm 2 in the town revealed a striking difference with the children of Farm 1. In this group, all children were enthusiastic about going to town. Beforehand, they had been looking for their best clothes and they could not wait to go. At the location they did not listen to the instructions, because they were eager to start immediately. The children showed great enthusiasm and competitive behaviour; they ran across the streets and asked strange people to help them answering the questions. There was only one observation of verbal aggression. However, there was also little social behaviour. When some of the smaller boys stayed behind, the elder boys ran away and did not notice they were missing some group members. A couple of times a child had to be warned to prevent it from running under a car. After the activity the children were willing to cooperate in answering the questions, but they found it hard to keep their attention. In general, the children were enthusiastic and cooperative and showed little aggressive behaviour. However they also displayed little social behaviour and much inattentive, impulsive and hyperactive behaviour.

General Environmental Evaluation

The children of Farm 2 generally evaluated both settings more positively than the children of Farm 1 (Table 3, first row). In addition, the children of Farm 1 evaluated the woods somewhat more positively than the town, whereas the children of Farm 2 evaluated the woods less positively than the town. This interaction effect between setting and group did not reach significance. However, the fairly large effect size of .08 indicates that this interaction effect may reflect a substantive finding.

Table 3. Means (\pm standard deviations) of dependent variables as a function of setting and group

	Woods	Town	Main effect setting		Main effect group		Interaction group \times setting	
			η^2	<i>P</i>	η^2	<i>P</i>	η^2	<i>P</i>
General evaluation (1–3)	2.05 \pm 0.48	2.12 \pm 0.63	.01	ns	.55	<.01	.08	.36
Farm 1	1.8 \pm 0.18	1.7 \pm 0.35						
Farm 2	2.3 \pm 0.56	2.53 \pm 0.58						
Restorativeness (1–3)	2.2 \pm 0.64	1.8 \pm 0.78	.32	<.01	.22	<.05	.37	<.01
Farm 1	2.0 \pm 0.50	1.2 \pm 0.25						
Farm 2	2.37 \pm 0.76	2.4 \pm 0.63						
Mood (1–7)	5.34 \pm 0.84	5.04 \pm 1.01	.09	.32	.01	ns	.12	.25
Farm 1	5.47 \pm 0.71	4.81 \pm 1.33						
Farm 2	5.22 \pm 1.0	5.28 \pm 0.60						
Concentration (s)	3.20 \pm 1.39	3.82 \pm 2.47	.21	.07	.09	.19	.00	ns
Farm 1	2.76 \pm 1.51	3.02 \pm 2.24						
Farm 2	3.65 \pm 1.21	4.63 \pm 2.61						

Note: tests for environmental and group influences on concentration were adjusted for baseline values measured during the trial session at the farm. ns, not significant.

Perceived Restorativeness

The children of Farm 2 generally perceived both settings as more restorative than the children of Farm 1 (Table 3, second row). In addition, the woods were generally perceived as more restorative than the town. However, this significant main effect of setting was qualified by a significant interaction between group and setting. Only the children of Farm 1 rated the woods as more restorative than the town; the children of Farm 2 did not differentiate much between the two settings.

Mood

The children generally reported somewhat more positive feelings in the woods than in the town (Table 3, third row). However, only the children of Farm 1 reported somewhat more positive feelings in the woods than in the town. The children of Farm 2 did not differentiate much between the two settings; they reported positive feelings in both settings. Although the interaction effect between group and setting did not reach significance, the large effect size of .12 indicates that it may represent a substantive finding.

Concentration

The scores on the concentration test are given in the last row of Table 3. Higher scores indicate that the child took more time to reverse the numbers in the opposite world, and thus had more difficulties with concentration. In each group, children had more difficulties to concentrate in the town than in the woods. Although this main effect of setting was only marginally

significant, the very large effect size of .21 indicates that it is a substantive finding.

Conclusion and discussion

This study used a mix of qualitative and quantitative measures to examine the behaviour and emotional and cognitive functioning of children with ADHD in a natural and a built environment. Two groups of six children, who stayed at care farms for children with ADHD in the Netherlands, were observed and tested in a wooded area and in a small town. Based on previous research on health benefits of nature for children, it was expected that the children would respond better to the natural than to the built setting. These expectations were only partly confirmed. Both groups performed better on a concentration task in the woods than in the town, despite the fact that all children visited the town after visiting the woods and thus their scores in the town were possibly inflated by learning effects and the general therapeutic influence of staying at the farm. However, behaviour and emotional functioning in the two settings differed between the groups. The children of Farm 1 liked the woods better than the town and displayed more positive behaviours and feelings in the natural environment. The children of Farm 2 liked the town equally well as the woods and displayed positive behaviours and feelings in both settings, although they showed somewhat more non-social, aggressive, inattentive, impulsive and hyperactive behaviour in the town than in the woods. In general, the present study found that children with ADHD functioned at a constant high level in the woods, whereas they displayed more variable behaviours and feelings and a generally low level of cognitive functioning in the built setting.

The present findings are consistent with parental reports of a positive influence of natural settings on symptoms of ADHD in their child (Faber Taylor *et al.* 2001; Kuo & Faber Taylor 2004). The findings are also in line with previous experimental research showing that children with ADHD concentrate better after a walk in the park (Faber Taylor & Kuo 2009). It should be noted, however, that the design of the present research does not allow for a direct causal attribution of the behaviour and functioning of the children to the physical settings. Other social or situational factors may have contributed to the findings. For example, it is possible that the adults who accompanied the children experienced some positive or negative influences from the physical settings, which may have affected their behaviour towards the children. Thus, the present research allows for several interpretations with regard to the differences in functioning of the children between the environmental conditions.

Apart from ADHD children's behaviour in specific settings, the present research also provides some more general insights into the living circumstances and environmental preferences of children with ADHD. In particular, we found that most of the children in this study had little space and few play opportunities in and around their homes. When they played outdoors, the children mostly played in non-natural settings, and they also indicated a preference for playing in these settings. These findings should be interpreted with caution, because the sample was very small and may not be representative of children with ADHD in general. However, they are consistent with recent insights that symptoms of ADHD tend to become more visible in settings that provide little freedom of movement and place high constraints on children (Purper-Ouakil *et al.* 2004).

By situating our study on a weekend farm for children with ADHD we were able to go beyond prior research on the connection between nature and ADHD in two important ways. First, we could collect first-hand data from the children themselves as they actually engaged with the settings, instead of having to rely on parental reports (Wells 2000; Faber Taylor *et al.* 2001; Kuo & Faber Taylor 2004). Moreover, we were able to examine the children in a familiar context as they interacted with friends and were surrounded by trusted people, rather than in an artificial experimental context (Faber Taylor & Kuo 2009). Apart from these advantages, it is important to note some limitations. Because we were guests at the OjeeADHD farms, we had had to adjust our research protocol to the farms' rules and organization. As a result, we could not randomly assign children to the two groups, or systematically vary the order in which the children visited the settings. It was also not possible to demand that the children remained unmedi-

ated. Furthermore, we encountered several unexpected events which necessitated changes in the protocol that may have influenced the results, such as the sick call of a staff member. Because of these limitations, and considering the small size and heterogeneous clinical picture of our sample, the results of the present study must be viewed as preliminary and caution is advised in generalizing from these data to other groups and contexts.

An important challenge for society is to respond to growing numbers of children with ADHD by fostering innovation and improvement in the early identification and treatment of this disorder. Despite its limitations, the present study has revealed indications of improved functioning of children with ADHD in a natural setting that are consistent with a larger body of work showing health benefits of nature for adults and healthy children (Kahn & Kellert 2002; Health Council of the Netherlands 2004; Van Den Berg *et al.* 2007a). Although most of this work has been concerned with temporary effects of discrete nature experiences, there is also growing evidence for long-term accumulative health benefits of regular contact with nature in the daily living environment (Mitchell & Popham 2008; Maas *et al.* 2009; Van Den Berg *et al.* 2010). These accumulating findings may be of practical importance to professionals who work with children with ADHD (e.g. teachers, mental health professionals, and paediatricians). For example, schools could use these findings to organize more trips into nature or have some lessons or after-school activities outdoors (Bentsen *et al.* 2009). Such small changes in the curriculum may provide temporary or maybe even longer-lasting reduction in symptoms that may allow more children with ADHD to stay in regular schools. This could reduce the demand on special schools and create better future career opportunities for the children.

In conclusion, findings of the present and previous research suggest that the natural environment can play a role in the reduction of symptoms of ADHD. These findings are important because there is an increasing demand for alternative complementary treatment of ADHD from parents and professionals who are uncomfortable with the prospect of long-term use of pharmacologic treatments (Sawni 2008). Thus far, however, research on environmental influences on ADHD has mostly focused on the prenatal womb environment and the social environment, while the physical environment has received little attention (Daley 2006). In general, many key questions regarding the role of the physical environment in the prevalence and treatment of ADHD remain unanswered. More research in this area is therefore certainly needed and recommended.

Key messages

- Parents of children with ADHD often perceive a reduction in symptoms after their child has played in a natural setting. This suggests that contact with nature can relieve ADHD symptoms.
- Research among healthy children has shown that contact with nature can positively influence cognitive, emotional, and physical functioning.
- The results of the present study show that children with ADHD generally liked going into the woods and displayed few symptoms in this natural environment.
- Although some children liked going into town, all children displayed problematic behaviours and concentration problems in the built environment.
- There is a need for more research on relationships between the physical environment and ADHD.

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