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Could Exposure to Everyday Green Spaces Help Treat ADHD? Evidence from Children's Play Settings

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Background: An estimated 4.4 million children in the United States suffer from Attention Deficit/Hyperactivity Disorder (ADHD), and most would benefit from a low-cost, side-effect-free way of managing their symptoms. Previous research suggests that after isolated exposures to greenspace, children's ADHD symptoms are reduced. This study examined whether routine exposures to greenspace, experienced through children's everyday play settings, might yield ongoing reductions in ADHD symptoms. **Methods:** Data on 421 children's ADHD symptoms and usual play settings were collected using a national Internet-based survey of parents. **Results:** Findings suggest that everyday play settings make a difference in overall symptom severity in children with ADHD. Specifically, children with ADHD who play regularly in green play settings have milder symptoms than children who play in built outdoor and indoor settings. This is true for all income groups and for both boys and girls. Interestingly, for hyperactive children, the apparent advantage of green spaces is true only for relatively open green settings. **Conclusions:** These and previous findings collectively suggest that it is time for randomised clinical trials testing the impacts of regular exposure to greenspace as a treatment for ADHD.

Keywords: ADHD, children, greenspace, home-range, play, treatment, USA

INTRODUCTION

Attention Deficit/Hyperactivity Disorder (ADHD) is the most commonly diagnosed behavioral disorder in children. All children have moments of deficient attention and impulse control, but in roughly 8 per cent of US children, these deficits are severe and chronic, and substantially disrupt functioning in multiple domains of life (Center for Disease Control [CDC], 2005). A high proportion of children with ADHD experience significant impairments in school performance: ADHD is associated with poor grades, poor

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standardised test scores on reading and math, higher rates of grade retention, and low rates of graduation (for review see Loe & Feldman, 2007). Similarly, a high proportion of children with ADHD experience significant impairments in social interaction, resulting in more frequent conflicts with family and peers, more frequent rejection by peers, and fewer friendships (for review, see Nijmeijer et al., 2008).

The Current Toolkit for Managing Attention Deficits

The current "toolkit" of available ADHD treatments contains two kinds of tools—pharmacological and behavioral interventions. The American Academy of Pediatrics (2001) recommends stimulant medications as the primary treatment for most children with ADHD (Brown et al., 2005), and indeed, in the US most children diagnosed with ADHD receive medication (Olfson, Gameroff, Marcus, & Jensen, 2003; Guevara, Lozano, Wickizer, Mell, & Grephart, 2002). Stimulant medications can improve control of attention, impulsivity, and hyperactivity (Brown et al., 2005), and there is some evidence of long-term gains in academic achievement as a result of their use (Scheffler et al., 2009). Non-stimulant medications such as tri-cyclic antidepressants may also be effective, but at this time are only recommended for children who have intolerable adverse effects from stimulant medications (for review, see Brown et al., 2005). Behavioral interventions such as positive reinforcement of desirable behaviors have been shown to have some, though limited, effectiveness in helping children improve social skills and to reduce problem behavior when consistently applied (for reviews, see Chronis, Jones, & Raggi, 2006; Brown et al., 2005). When coupled with stimulants, behavioral interventions may lower the dose of medicine children with ADHD need and improve their interpersonal skills and relationships more so than medication alone (for reviews, see Brown et al., 2005; American Academy of Child and Adolescent Psychiatry and American Psychiatric Association [AACAP & APA], n.d.; Chronis et al., 2006).

Unfortunately, current pharmacological treatments have several major shortcomings. Stimulant medications entail serious side-effects, including reduced appetite, weight loss, irritability, headaches, stomach pain, insomnia, and delayed growth (AACAP & APA, n.d.; American Academy of Pediatrics [AAP], 2001; Wolraich, McGuin, & Doffing, 2007). The only non-stimulant medication approved by the FDA for ADHD treatment also has serious side-effects, including appetite suppression, weight loss, liver problems, and the potential for suicidal thoughts (for review, see Brown et al., 2005; AACAP & APA, n.d.; Wolraich et al., 2007). Furthermore, stimulants are not effective at all for nearly 30 per cent of children (Jensen et al., 2001; Biederman & Spencer 2008). Even among children who respond to medications, their effectiveness is often limited due to improper dosage.

Contributing factors include insufficient number of follow-up visits with a physician to adjust dosage, a tendency on the part of physicians to underdose, and hesitation among parents to give their children the quantity of medication necessary to reach a normal range of functioning (for review, see Jensen et al., 2001). Given the cost and side-effects of stimulant medications (e.g. Hong, Dilla, & Arellano, 2009), it is not surprising that many families do not adhere to stimulant medication regimens, or discontinue them without consulting their physician.

Behavioral treatments for ADHD have their limitations as well. As yet, their efficacy has only been clearly demonstrated in clinical settings, partly due to the difficulty of consistently applying these treatments in the real world. While psychosocial treatments can be effective in combination with medications, it has yet to be proven that coupling psychosocial treatments with stimulant medications is any more effective at reducing core symptoms than administering medications alone (for reviews, see Brown et al., 2005; AACAP & APA, n.d.; Chronis et al., 2006). They are not recommended by the AAP as a stand-alone treatment (for review, see Brown et al., 2005; Weiss, Yeung, Rea, Poitras, & Goldstein, 2009).

A Possible New Tool for Managing Attention Deficits

If everyday exposure to greenspace reduces children's attention deficit symptoms on an ongoing basis, it could be an important new tool in the toolkit for managing ADHD. First, unlike medications and behavioral therapies, "regular green time" is likely to be well accepted as a treatment modality. Parental lore already includes the notion that "fresh air" and time outside is good for children, and there is evidence that children are drawn to natural settings (e.g. Sobel, 1993). Further, forms of greenspace ranging from neighborhood parks to shady back yards are often widely available at no cost. Window views of greenspace could also provide routine exposure at little cost and may also enhance attention (Faber Taylor, Kuo, & Sullivan, 2002; Kaplan, 2001). Regular exposure to green settings would not have any of the negative side-effects associated with medications—and if an afternoon or evening dose of "nature" instead of medication provided adequate relief, perhaps that would allow children to recover their appetite in time for dinner and get a good night's sleep on a regular basis. Finally, regular exposure to greenspace and more time spent outdoors are likely to yield a variety of additional benefits for children. More time outdoors is linked to greater physical activity (Sallis, Prochaska, & Taylor, 2000; for review, see Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008), which in turn is related to better health (e.g. Andersen et al., 2006; Carrel et al., 2005; Bayer, Bolte, & Morlock, 2009), cognitive functioning and academic achievement (e.g. Hillman et al., 2009; Castelli, Hillman, Buck, & Erwin, 2007; Caterino &

Polak, 1999). For all these reasons, the potential of regular green time for treating ADHD is worth investigating.

Do routinely experienced greenspaces have systematic effects on children's ADHD symptoms? Currently, the scientific literature on this question is unresolved. A review of the existing evidence suggests that while the effects of relatively isolated, acute exposures to greenspace on ADHD symptoms are fairly well established, the effects of relatively routine, chronic exposure are less clear-cut.

It is helpful here to distinguish between relatively *routine* and *isolated* exposures. By routine exposures, we mean exposures to greenspace that occur on a daily or near daily basis in the places where children routinely spend time—home, school, and after-school play settings. These exposures occur as a matter of course as children go through their normal day—the grassy recess area at an elementary school, the tree-lined street through which a middle-schooler bikes home after school, the shady view that a high school student looks out on while doing their homework in the afternoon. Routine exposures to greenspace might or might not involve specific activities: daily soccer practice would constitute a routine exposure, but so would "hanging out" in the backyard, doing a variety of things. The advantage of routine exposures to greenspace as a potential treatment modality is that they are, or can easily be, part of a child's daily routine.

By *isolated exposures*, we mean exposures to nature that are not part of the daily round of activities—a parent-child walk at the nature center, the weekend camping trip, going kayaking at the state park an hour away, the road trip across the country to see Rocky Mountain National Park or Acadia. These exposures tend to be special events; they require planning and effort. Isolated and routine exposures exist on a continuum, of course; a junior high school student might have soccer practice on Monday and Wednesday afternoons, with matches every weekend. Nonetheless, the distinction between routine and isolated is useful in that relatively routine exposures to greenspace can easily lend themselves for use as a regular means of symptom reduction, whereas relatively isolated exposures do not. It is one thing to sign up a child who loves soccer for regular practice and then chauffeur them to meets; it is another to undertake that commitment solely as a regular means of treating ADHD. From a practical standpoint, it is important to know whether routine exposures to greenspace can provide continuing symptom relief. Below, we review the theory and evidence on the effects of routine and isolated exposures to greenspace on ADHD.

Attention restoration theory (Kaplan, 1995; Kaplan, S., 2001) gives an explanation for why exposure to greenspace is rejuvenating; it does not draw any explicit distinction between routine and isolated exposures, but a closer look at the theory suggests some reasons why we might expect routine expo-

sures to be less effective than isolated exposures in reducing ADHD symptoms. Attention restoration theory proposes that our capacity to actively direct our attention and tune out distractions is a limited resource; with overuse, it fatigues and becomes less effective (Kaplan, 1995). With rest—that is, during sleep and during gently absorbing activities that draw primarily on an effortless form of attention called involuntary attention—the capacity to direct attention recovers (Kaplan, 1995). Attention restoration theory specifies the qualities an environment must have to promote attention restoration, and proposes that natural environments tend to have these qualities. To the extent that greenspaces retain these qualities when they become deeply familiar, we would expect routine exposures to these spaces to have continuing salutary effects on ADHD symptoms. However, it seems plausible that two of the qualities specified in attention restoration theory might systematically lessen or disappear with habituation—specifically, as a setting becomes increasingly familiar, it seems plausible that the setting will hold less fascination and provide less of a sense of "being away" for the individual. If so, routine exposures to greenspace might offer less or even no relief from ADHD symptoms.

The empirical literature on the effects of routine and isolated "doses" of nature is complicated. One quasi-experimental study on ADHD and "doses of nature" examined the effects of a relatively isolated "dose". It compared the effects of a 20-minute guided walk through a park, versus guided walks through other, less green but otherwise carefully matched settings, and found that children with ADHD performed significantly better on an objective measure of concentration immediately after the park walk than after the other walks (Faber Taylor & Kuo, 2009). In that study, the settings were chosen to be relatively unfamiliar to the participants, and were not part of any of the participants' regular routine.

Two correlational studies on ADHD did not study "isolated" exposures per se, but examined the impacts of specific leisure activities without specifying whether those activities were routine or isolated. In those studies, single leisure activities conducted in green outdoor settings were consistently rated significantly higher for symptom reduction after the activity than activities conducted in relatively built outdoor or indoor settings (Faber Taylor, Kuo, & Sullivan 2001; Kuo & Faber Taylor, 2004). Furthermore, the relationship between activities in relatively green settings and improved attention held across many subpopulations, e.g. children with and without hyperactivity (Faber Taylor et al., 2001; Kuo & Faber Taylor, 2004), and settings, e.g. from rural areas to large cities and across all regions of the US (Kuo & Faber Taylor, 2004). These findings suggested that "green time" might be helpful in reducing ADHD symptoms across boys and girls across different ages, living in different community sizes in different regions of the country. Further, these findings suggested that "green time" benefits are compatible with a very wide

range of activities, from nature-focused activities such as fishing and camping, to activities that do not center on nature but can take place in relatively green settings, such as reading in a shady backyard or playing basketball in a neighborhood park. What these findings left unclear was whether activities in green settings retain their effectiveness when they are routine.

Findings for the effects of routine exposures to greenspace on ADHD symptoms are complex. Routine exposures to greenspace are likely to occur in three main settings: school, home, and play. While no research has examined the impacts of school greenspace on ADHD symptoms, the potential impacts of home greenspace and play greenspace have been studied. Findings were mixed. In a Midwestern sample of 96 7–12-year-old children, the greenness of a child's usual playspace was significantly related to ADHD symptoms, but the greenness of their home was not, for any of the measures of residential greenness—overall greenness, grass cover in the front and back, or tree cover in the front and back (Faber Taylor et al., 2001).

Why would routinely experienced greenspace be linked with milder symptoms overall when experienced through play settings but not home settings? One possible interpretation is that children are more habituated to their home settings, and as a consequence "home greenspace" is less fascinating, provides less of a sense of being away than other greenspaces, and is less effective in restoring attention than other green settings. However, a number of findings argue against this interpretation: in the study above, while no significant link between home greenspace and ADHD symptoms was found for the sample overall, a significant link was found for girls. ADHD symptoms were significantly milder for girls with greener homes, for several measures of residential greenness (Faber Taylor et al., 2001). Moreover, in studies of residential nature and attention in the general population (that is, children not specifically sampled from the ADHD population), home greenspace and better attention have been linked in a mixed-gender sample (Wells, 2000) and for girls but not boys in another study (Faber Taylor et al., 2002). At present, it is difficult to say why routine exposures are sometimes linked to better attention, and sometimes not.

This Study

The data reported here help address a number of puzzles and unanswered questions in previous work. The findings linking routine greenspace exposures and reduced ADHD symptoms are inconsistent (Faber Taylor et al., 2001), as are the hints of gender differences in responses to greenspace exposure (Faber Taylor et al., 2001, 2002). A larger, national sample may reveal one or another of these findings or nonfindings to be a fluke. Further, if a link between routine greenspace exposure and reduced ADHD symptoms is

found, a larger sample may make it possible to determine whether this link is explained by family income. If wealthier families have both routine access to greener spaces and generally more supportive circumstances, those circumstances might be responsible for systematically milder ADHD symptoms. Finally, a larger sample would make it possible to follow up on hints in previous work that children with different ADHD diagnoses might not respond in the same way to different kinds of green settings. In an Internet-based survey, we gathered data from a large national sample of parents of children with ADHD about their child's everyday play setting[1] and overall symptoms; this sample provides a more geographically representative sample of children in a wide variety of ecosystems, thus improving the generalisability of findings.

METHODS

The data presented here are part of a larger data set; that larger data set included information on children's usual play environments and overall ADHD symptoms (previously unpublished, and now presented here), as well as information on the after-effects of different activities on a given child's symptoms (published in Kuo & Faber Taylor, 2004).

Participants and Procedure

Recruitment. Parents and legal guardians of children with ADHD were recruited via advertisements placed in major US newspapers and via the website of Children and Adults with Attention-Deficit/Hyperactivity Disorder (http://www.chadd.org), the largest national, nonprofit organisation in the United States serving individuals with ADHD. Information on the study was posted on the Internet from 15 September to 31 October 2000. Potential participants were invited to take part in "a national study on how different activities affect children's ADHD symptoms". Two incentives were offered: a list of recommendations for coping with ADHD based on the study's findings and the chance to win a gift certificate. Participants completed an informed consent form before accessing the first page of the survey.

Response and Final Sample. In the 47 days during which the study was posted, the website received 1,053 unique hits. Access to the questionnaire itself was restricted to individuals whose responses to screening questions met

[1] We acknowledge that using the label "play settings" is somewhat inaccurate since the sample included youth up to 18 years old, and teenagers don't really have "play settings" but are more likely to have "leisure" settings. Nonetheless, for brevity we will simply use the label "play settings" for the entire sample.

the sampling criteria: parents or legal guardians of children aged 5–18 years formally diagnosed with ADHD by a physician, psychologist, or psychiatrist. Approximately 30 per cent ($n = 315$) of visitors did not meet the sampling criteria, most frequently because the child had not been professionally diagnosed. Of the qualified visitors (738), 71 per cent ($n = 524$) went on to fill out at least a portion of the 20- to 30-minute survey. Five surveys were unusable owing to computer error. Of the 519 usable surveys, 81 per cent ($n = 421$) included responses to the portion of the survey reported here. The analyses reported here were based on 421 surveys, including six from the Spanish version of the questionnaire.

Parents reported their child's age, sex, diagnosis (ADD or ADHD), and the household income. The age distribution of children in this sample was as follows: 72 children were 5 to 7 years old, 164 children were 8 to 10 years old, 110 were 11 to 13 years old, and 54 were 14 to 18 years old. Eighty per cent ($n = 335$) were boys, and 20 per cent ($n = 86$) were girls. To report diagnosis information, parents answered the survey item, *Which has your child been diagnosed with: ADD or ADHD?* and could select one of three categories: *ADD* ($n = 102$), *ADHD* ($n = 312$), or *don't know*.[2] Parents also completed the survey item, *Total gross annual household income* by marking one of the following categories: *<$10,000* ($n = 9$); *$10,000–24,999* ($n = 36$); *$25,000–49,999* ($n = 114$); *$50,000–74,999* ($n = 106$); *≥$75,000* ($n = 123$). Fifty-nine per cent of the parents reported their household income to be $50,000 or greater. *Applied Psychology* readers interested in knowing more about the geographic and community characteristics of the sample can find this information in Table 1 in Kuo and Faber Taylor (2004).

Measurement

Assessing Play Settings' Relationship to Overall Symptom Severity. In the questionnaire, parents answered questions about their child's overall symptom severity and their child's everyday play setting. Parents answered the question *In general, how severe would you say your child's ADD or ADHD symptoms are (when not on medication)?* using a 5-point Likert scale, from 1 = *very mild* to 5 = *very severe* with *average* as the mid-point. Nearly one-third (29%) of the children were rated as having *average* severity of symptoms, whereas more than half (62%) had symptoms that were rated as *severe* or *very severe*. The mean rating of children's overall severity of symptoms ($M = 3.69$, $SD = .89$) fell between *average* and *severe* on a range of *1* (*very mild*) to *5* (*very severe*).

[2] At the time of the study the labels "ADD" and "ADHD" were still the commonly used labels for differentiating between children with and without hyperactivity.

TABLE 1
Response Options for Survey Item, "Where did your Child Play in the Last Week?", number of Children Playing in Each Setting, and Percent of Total Sample

Survey category	*Category abbreviation*	N	*% of children*
Places where there are big trees and grass	Big Trees & Grass	132	31
Places indoors where it feels very much indoors	Deep Indoors	110	26
Places where there is a lot of open grass	Open Grass	45	11
Places that are paved or built	Built Outdoors	38	9
Other (fill in the blank)	Other	38	9
Places where there might be "wild" things	Wild places	26	6
Places indoors where it feels almost like you are outdoors	Indoors with Windows	15	4
Waterfront (lakes, ocean, rivers, ponds, creeks, etc.)	Waterfront	9	2
Barnyard or farmland	Barnyard/Farmland	6	1
Desert landscape (little vegetation, mostly sand, rocks, etc.)	Desert	2	0.5
Public indoor spaces (shopping malls, museums, libraries, etc.)	Public Indoors	0	0
Total responses to this survey item		421	99.5

Parents were also shown example photos of different categories of settings, and were asked, *Where did your child play in the past week? Below you'll see 10 descriptions of where kids might play. Please mark one box where the description sounds most like where your child played most of the time after school and on the weekends during the past week. For some of the descriptions we have provided examples*. The descriptions were as follows and an example photo was included for the first six: *Places where there are big trees and grass*; *Places indoors where it feels very much indoors*; *Places where there is a lot of open grass*; *Places that are paved or built*; *Places where there might be "wild" things*; *Places indoors where it feels almost like you are outdoors*; *Waterfront (lakes, ocean, rivers, ponds, creeks, etc.)*; *Barnyard or farmland*; *Desert landscape (little vegetation, mostly sand, rocks, etc.)*; *Public indoor spaces (shopping malls, museums, libraries, etc.)*. Parents also had the opportunity to choose "Other" and type their own description in a blank text box (see Figure 1 and Table 1). Parents were asked to select one category as representative of where their child played during the previous week. "The previous week" was specified as a time frame because it placed a minimal memory load on participants, and because the questionnaire was given at a time of year during which children might feasibly play outside.

Parents were then asked, *Is that where your child typically plays*? (*yes /no*). This question assesses whether their child's activities in the previous week

Places where there are big trees and grass (Big Trees & Grass)

Places where there is a lot of open grass (Open Grass)

Places indoors where it feels very much indoors (Deep Indoors)

Places that are paved or built (Built Outdoors)

FIGURE 1. Example photos from survey item, "Where did your child play in the last week?" Category descriptions with abbreviations in parentheses.

were representative of the child's normal routine. Of the 397 parents who answered the question, 89 per cent answered, "Yes".

RESULTS

The findings here provide a picture of where children with ADHD play, and the relationship between children's play environments and their symptoms. Analyses address five questions: Where do children with ADHD play? Are greener play environments related to less severe ADHD symptoms? Can the relationship between greener play environments and less severe symptoms be explained by family income? Are there gender or diagnosis differences in where children play or in the relationship between play settings and symptoms? And finally, how does the effect of greenness of a child's routine play setting compare to the effects of their gender, diagnosis, and family's income?

Where do Children with ADHD Play?

Table 1 provides the distribution of children across different play settings based on parents' reports of their child's most frequent play setting during the previous week. Because not all (89%) children were in their "typical" play setting, we compared the distribution of children across play settings for the whole sample versus the children in their "typical" play setting. A chi-square analysis indicates that the distributions were not significantly different from each other, X^2 (8, $N = 419$) = 1.37, $p = .99$; thus, we report the distribution for the whole (larger) sample.

If the 10 play settings are clustered into broader categories, we see that most (60.5%) of the children played in some kind of outdoor setting and 30 per cent played indoors, with 9 per cent in an "other" setting. Of the 10 play settings, only four had reasonably large sample sizes ($n \geq 30$): *Big Trees & Grass*, *Deep Indoors*, *Open Grass*, and *Built Outdoors*. For all remaining analyses in which we characterise children's choice of play settings, we examine children's distribution among those four settings and a catchall "other" setting. For analyses in which we examine the effect of different play settings on ADHD symptoms, we focus on only the four main play settings (it does not seem meaningful to determine what symptoms are associated with a highly heterogeneous "Other" setting).

Are Greener Play Environments Related to Less Severe ADHD Symptoms?

To examine whether greener play environments are related to milder ADHD symptoms overall, we compared parents' ratings of the severity of their child's symptoms across the four most common play settings.

An ANOVA testing for a relationship between symptom severity and setting revealed a significant main effect of setting, $F(3, 321) = 5.78$, $p < .001$ (see Figure 2). A series of pair-wise contrasts using Fisher's protected least significant difference (Fisher's PLSD) shows which settings are linked with more severe symptoms. Children playing in the two relatively built settings had more severe symptoms than did children playing in the two green settings. Children playing *Deep Indoors* had significantly more severe symptoms than did children playing in either of the two green settings—more severe symptoms than children playing in *Open Grass* ($d = .57$, $p < .001$) and more severe symptoms than children playing in settings with *Big Trees & Grass* ($d = .25$, $p < .05$). Further, children playing in the other built setting, *Built Outdoors*, had significantly more severe symptoms than did children playing in the two green outdoor settings. *Built Outdoors* related to more severe symptoms than *Open Grass* ($d = .64$, $p = .001$), and *Big Trees & Grass* ($d = .31$, significant at

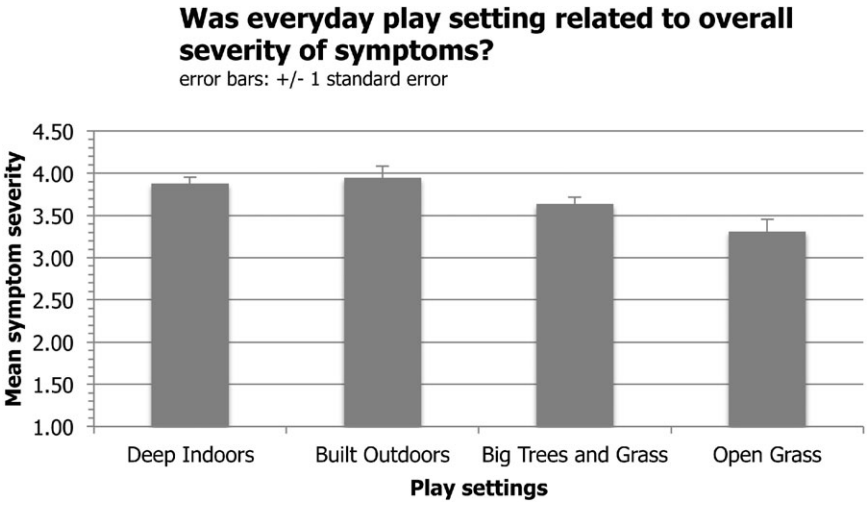

FIGURE 2. Mean symptom severity of children in four common play settings.

$p = .05$).[3] Surprisingly, children playing indoors (*Deep Indoors)* did not have significantly more severe symptoms than those playing outdoors in *Built Outdoor* settings ($d = .07$, $p = .69$). Also noteworthy, symptom ratings for *Big Trees & Grass* were significantly different from those for *Open Grass*. Children playing in environments with *Big Trees & Grass* had more severe symptoms than did children playing in *Open Grass*, $d = .33$, $p < .05$.[4]

To put it another way, *Big Trees & Grass* and *Open Grass* were associated with milder symptoms than *Built Outdoors* and *Deep Indoors*, and *Open Grass* was associated with the mildest symptoms of all.[5]

Does Family Income Explain the Relationship?

To examine whether the link between greener play settings and milder symptoms might be explained by income, we tested for whether household income was related to severity of symptoms, on the one hand, and greenness of play

[3] A restricted sample (only those children who were playing in their typical play setting) shows the same relationships as the whole sample, with the exception of *Built Outdoors play* that was no longer linked with significantly more severe symptoms than *Big Trees & Grass*, $d = .22$, $p = .22$.

[4] In the restricted sample (children in their typical play setting) *Big Trees & Grass* was no longer linked with significantly more severe symptoms than *Open Grass*, $d = .24$, $p = .13$.

[5] While not included in the ANOVAs, we feel it is important to note that counter to expectations for "the greener the better", *Wild places* ($n = 26$) had a severity rating of 3.77 (thus fitting somewhere between *Big Trees & Grass* and *Deep Indoors*).

setting, on the other. Income was significantly related to the severity of symptoms; household income was negatively related to severity of symptoms, $R^2 = .01$, $F(1, 386) = 4.75$, $p < .05$, indicating that the larger a child's household income, the milder their symptoms were rated. However, income did not vary significantly by play setting. An ANOVA comparing mean family income for each of the four play settings indicated no significant differences, $F(3, 299) = .14$, $p = .94$. Thus the milder symptoms seen in children playing in greener settings cannot be explained by differences in income.

Play Environment and Symptoms for Boys and Girls

Given the well-established gender differences in children's play, we thought there might be differences in the general categories of environment that boys vs. girls choose to play in, as well as in the effects of play environment on boys' vs. girls' symptoms. However, we found no such differences. A chi-square test for independence indicated no significant difference between girls and boys in their distribution across different play environments, X^2 (4, $N = 421$) = 6.37, $p = .17$.[6] And a two-way ANOVA with environment and gender as factors in the severity of children's symptoms showed no interaction between environment and gender, $F(3, 317) = .18$, $p = .91$. There was also no gender difference in the severity of children's symptoms, $F(1, 317) = .50$, $p = .48$. The effect of environment was significant, as expected, $F(3, 317) = 3.88$, $p < .01$.[7]

Play Environments and Symptoms in Children with and without Hyperactivity

We wondered whether the hyperactivity component of ADHD might affect children's choice of play settings, and whether the play settings best for hyperactive children might differ from the settings best for children without hyperactivity. To examine whether children with different diagnoses tend to play in different settings, we compared the play environments reported for children with and without hyperactivity, using a chi-square test for independence for the distribution across the four most common environments and a fifth category comprising all other play categories. While the distribution of children across different settings hints at some differences, these were not significant, X^2 (4, $N = 414$) = 6.96, $p = .14$. As Table 2 shows, there is a trend toward hyperactive children playing *Deep Indoors* and in *Built Outdoors*, and

[6] To capture the whole sample, this analysis included the four most common categories along with a fifth category comprising all the other play categories.

[7] Only 325 parents chose one of the four play settings analyzed here, hence the smaller sample size.

TABLE 2
Where Children With and Without Hyperactivity Play

	ADHD	*ADD*
Big Trees & Grass	29%	39%
Open Grass	10%	13%
Deep Indoors	28%	22%
Built Outdoors	11%	5%
Other	22%	22%

non-hyperactive children playing in places with *Big Trees & Grass*. Roughly equivalent numbers of children with and without hyperactivity were playing in *Open Grass*.

While children with and without hyperactivity showed no significant differences in their choice of play settings, we did find these two groups differ in how the four play environments related to their symptom severity. A two-way ANOVA testing for the effects of environment and diagnosis on the severity of a child's symptoms showed a significant interaction effect, $F(3, 314) = 4.06$, $p = .008$.[8] As Figure 3 shows, the effects of different settings on symptoms appear quite different for children with and without hyperactivity. If we examine the effects of different settings on symptoms for each population of children in turn, we see different profiles.

For children with hyperactivity (ADHD), playing in *Open Grass* was linked to less severe symptoms than each of the other three settings—*Big Trees & Grass* ($t(120) = -2.03$, $p = .04$), *Deep Indoors* ($t(117) = -2.49$, $p = .007$, one-tailed), and *Built Outdoors* settings ($t(63) = -1.76$, $p = .04$, one-tailed). (Contrasts between green and non-green settings were planned, and therefore one-tailed tests.) All pair-wise contrasts among the other three settings (*Big Trees & Grass*, *Deep Indoors*, and *Built Outdoors*) were non-significant.

For children without hyperactivity (ADD), the two "green" environments were linked with less severe symptoms than the two "non-green" settings (some of these contrasts are based on small *n*s). Pair-wise contrasts show that the two green environments were not significantly different from each other, the two built environments were not significantly different from each other, and each of the green environments was better than each of the built environments. Children with ADD who played in *Big Trees & Grass* had milder

[8] A two-way ANOVA testing for the effects of environment and diagnosis on the severity of a child's symptoms showed a significant main effect, $F(3, 314) = 8.19$, $p < .0001$. While the hyperactive/non-hyperactive groups did show significant mean differences in symptom severity, hyperactivity diagnosis did *not* show a significant main effect, $F(1, 314) = 2.86$, $p = .09$, and thus is not able to explain a significant amount of the variation in the children's severity of symptoms.

FIGURE 3. Setting and diagnosis interact in their relationship to symptom severity.

symptoms than those playing in either of the two non-green settings ($t(60) = -3.15$, $p = .001$, one-tailed, *Deep Indoors*, and $t(43) = -3.37$, $p = .0008$, one-tailed, *Built Outdoors*). Similarly, children with ADD who played in *Open Grass* have milder symptoms than those playing in either of the two non-green settings ($n = 13$, $t(33) = -2.97$, $p = .003$, one-tailed, for *Deep Indoors*, and $n = 5$, $t(16) = -2.87$, $p = .006$, one-tailed, for *Built Outdoors*). *Open Grass* was not significantly different from *Big Trees & Grass* ($p = .29$, two-tailed) for children with ADD. Furthermore, *Built Outdoors* was not significantly different from *Deep Indoors* ($p = .14$, two-tailed).

These findings suggest that children with ADD who routinely play in green outdoor spaces either with open grass or with large trees and grass have less severe symptoms than children who routinely play in built spaces—indoors without windows or highly built outdoor spaces.

In sum, the significant interaction between diagnosis and play setting can be captured as follows: for children with ADHD (hyperactive), the mildest symptoms are associated with *Open Grass*, whereas for children with ADD, the mildest symptoms are associated with both *Open Grass* and *Big Trees & Grass*.

Comparing the "Effect" of Green Play Settings versus Household Income, Gender, and Diagnosis

To examine the relative contribution of green play settings, income, gender, and diagnosis in predicting ADHD symptoms, a multiple regression was

TABLE 3
Severity of ADHD Symptoms Regressed onto Play Setting, Diagnosis, Gender, and Income Variables

Predictor variable	*Beta*	p-*value*
Green play setting / not green play setting	.162	0.004
Diagnosis (ADD/ADHD)	.178	0.002
Gender	.007	0.905
Income	–.037	0.513

Regression model summary: $F_{4,\ 298} = 5.34$, $p < .001$; Adjusted $R^2 = .054$.

conducted. This analysis indicates that when we combine the two green settings and the two built settings into a two-level (green/not green) play settings variable, the contribution of green play settings to ADHD symptoms is roughly as large as that for diagnosis, and larger than those for income and gender (which are not significant). Further, this analysis indicates that green play settings remain a significant predictor of ADHD symptom severity when diagnosis, income, and gender are controlled (see Table 3).

DISCUSSION

The purpose of this work was to further explore the possibility that routine exposures to greenspace might yield ongoing reductions in ADHD symptoms. Previous findings, based on a geographically limited sample of 96 children, were mixed. To pursue this question with a larger sample, we analyzed here the results of a national, Internet survey of 421 parents. Parents' reports suggest that children who regularly play in green outdoor settings experience milder ADHD symptoms than their counterparts playing indoors or in built outdoor settings. No gender differences were found, and findings indicated that the link between green playspaces and relatively mild symptoms could not be attributed to family income. Interestingly, for hyperactive children, the advantage of green outdoor play settings was true only for relatively open settings—"open grass". While not a primary focus of the study, the findings here suggest that children with ADHD seek out green outdoor settings at a substantially higher rate than has been reported in recent studies for children in the general population. We discuss each of these findings in turn.

Overall, Green Play Settings were Consistently Linked with Milder ADHD Symptoms than Non-Green Play Settings

In every comparison between *Open Grass* and non-green play settings, *Open Grass* was related to significantly lower symptoms: this pattern held for both

of the non-green play settings, for the entire sample and for the restricted sample (only those in their "typical" play setting), and for each subgroup—girls and boys, all income groups, and hyperactive and non-hyperactive children. Further, in almost every comparison between *Big Trees & Grass* and either of the non-green play settings, *Big Trees & Grass* was related to significantly lower symptoms; this relationship held for the entire sample, for the restricted sample, and for nearly all subgroups—girls and boys, all income groups, and non-hyperactive children.

No Gender Differences in the Greenspace–ADHD Symptoms Link were Found

Previous research raised the question of whether or not boys benefit from routinely experienced greenspace less than girls. It is noteworthy that with this large sample size, we were able to test for gender differences and found no evidence for any differences between boys and girls in the impact of routinely experienced greenspace on attentional functioning. The findings here suggest that the most parsimonious explanation for previous findings indicating that boys do not show significant effects of *residential* nature on their ADHD symptoms is that they tend not to play at home; this interpretation is lent credence by a similar pattern of findings in children without ADHD—one previous study involving children in the general population found significant effects of residential green on girls across a variety of measures, but no effects for boys (Faber Taylor et al., 2002).

For Hyperactive Children, Only One Type of Green Setting is Best for Symptoms

This study shows that hyperactivity diagnosis may moderate the apparent effect of greenness of play setting on symptom severity. Unlike *Open Grass*, *Big Trees & Grass* did not appear to be particularly beneficial for hyperactive children in this study. The current study suggests that for hyperactive children, greenness alone may not be enough to reduce symptoms. The most supportive play environments for children with strong impulses for large motor movement may be both green and open.

Children with ADHD may Play Outdoors Far More than Other Children

This study provides a glimpse into where a large number of children with ADHD regularly play after school and on weekends. Both folk theory and previous data in the general population suggest that today's children are spending more of their free time indoors than previous generations. Recent

popular press emphasises that children are not playing outdoors as much as they used to or as much as they should (e.g. Louv, 2005). In one national study, only 8 per cent of 9–12-year-old American children in the general population self-reported participating in outdoor activities (Hofferth & Curtin, 2006); in another national study, a survey of mothers in the US found that only 31 per cent of 3–12-year-old children play outdoors every day (Clements, 2004).

In contrast, the findings here suggest that a majority of children with ADHD routinely play outdoors. In this national sample of 421 children, many (60.5%) play outdoors; this finding closely tracks the results of a previous, smaller study of 96 children living in the midwestern United States, in which nearly 70 per cent of children played in one of the following outdoor settings: places with big trees and grass (44%), places where there is a lot of open grass (13%), places outdoors where there might be "wild" things (9%), or places outdoors that are paved or built (2%) (Faber Taylor et al., 2001). It is possible that the apparent differences between the children with ADHD in this study and the children in other studies of indoor/outdoor play are merely an artifact of the different survey methodologies used. However, it is also possible that children with ADHD show a substantially greater propensity to play outside than other children; an intriguing possibility that this raises is that many children are self-medicating in their choice of play settings.

Limitations and Questions for Future Research

One limitation in this study is in the measurement of "usual" play settings. In this study, we asked parents to select the type of setting where their child routinely plays, but we did not ask parents to estimate the actual amount of time their child spent in that kind of setting. Thus, some children might spend almost all their free time in their "usual" play setting; others might distribute their time widely among a variety of settings and spend more time in their "usual" play setting than in other settings, but still only a fraction of their free time. Further, as we had no way of confirming parents' reports as to their children's regular play settings, it could be that some parents were mistaken in their reports. Parent reports seem likely to be less reliable for older children; one wonders how well parents of children in their teens know where their children spend time.

It is worth noting that to the extent that children vary in the actual amount of time they spend in their "usual" play settings, and adults vary in how accurately they can identify their children's "usual" play settings, these sources of noise would make it more difficult to detect significant effects due to usual play settings. The fact that the relationship between green play settings and reduced symptoms is significant despite the likely variation in children's actual exposure suggests that the relationship is robust. Nonethe-

less, it is possible that the apparent effect of routine exposures to greenspace on ADHD symptoms found here is carried primarily by a subset of children who actually spend substantial time in the setting their parents *think* is their regular play setting, and by younger children in particular—unfortunately, there were not enough children over 13 years old to test that group separately. It seems likely that teens with ADHD will show the same effects of routine nature exposure, given the previous research in younger children with ADHD, younger children without ADHD, and teens and adults without ADHD (e.g. Berman, Jonides, & Kaplan, 2008; Matsuoka, 2010; Wells, 2000; Faber Taylor et al., 2001, 2002). Still, future research, most likely using self-report from teens or a tracking tool, should examine whether teens show the same leisure setting–symptom patterns.

A second limitation of this study is that it did not address the potential role of activities in the relationship between greenspace exposure and ADHD symptoms. A setting's impact on ADHD symptoms is likely to vary in important ways depending on the activity in which the child is engaged, and future research might examine the interactions between the effects of different settings and the effects of different activities on symptoms. It is possible that the differences in symptoms found for different settings here are at least partially driven by the kinds of activities that children engage in in those settings. It is worth noting, however, that previous work has shown significant effects of setting on ADHD symptoms even when activity is held constant across settings (e.g. Faber Taylor et al., 2001; Faber Taylor & Kuo, 2009; Kuo & Faber Taylor, 2004).

A third limitation is that these findings are correlational. Could children's symptom severity propel them to choose one play setting over another? For example, perhaps children with milder symptoms tend to play in greener play settings, while children with more severe symptoms tend to play in non-green settings. If that were the case, it would mean that symptom severity leads to setting rather than setting influencing symptom severity. This possibility must be considered in the context of a substantial body of literature showing that exposure to green settings is linked with improvements in attention in both ADHD and neurotypical populations (e.g. Berman et al., 2008; Faber Taylor et al., 2001, 2002; Kuo & Faber Taylor, 2004; Wells, 2000; Faber Taylor & Kuo, 2009; Hartig, Evans, Jamner, Davis, & Garling, 2003). Nonetheless, future studies should randomly assign children to routine exposures to greenspace or more built settings.

Children Benefit when Greenspace is a Part of Daily Life

The current findings echo previous findings pointing to the importance of building communities with easily accessible greenspaces. Previous findings have linked contact with everyday greenspace with positive attentional func-

tioning in both children with ADHD and children in the general population (Faber Taylor et al., 2001, 2002; Kuo & Faber Taylor, 2004; Faber Taylor & Kuo, 2009; Wells, 2000). Moreover, everyday greenspace, specifically greenspace near the home, has also been linked with myriad other benefits such as: greater impulse control and delay of gratification, and fostering more play, more creative forms of play, greater capacity to cope with stress, and adult supervision (for review, see Faber Taylor & Kuo, 2006), as well as lower rates of obesity (e.g. Liu, Wilson, Qi, & Ying, 2007). Thus it seems worthwhile for communities to make greenspace accessible as part of children's daily routines through greening schoolyards, planting residential street trees, and providing neighborhood parks. Further, the current findings show that for some children, more "open" greenspaces may be particularly beneficial. Communities may want to provide not only densely planted greenspaces, such as traditional parks with mature shade trees, but also provide greenspaces in which trees and shrubs are clustered to allow for larger expanses of open grass.

Implications for Greenspace as a Potential Treatment for ADHD

These findings reinforce and extend previous findings that time in greenspace may mitigate children's ADHD symptoms. Previous evidence suggests that isolated exposures to greenspace result in an immediate, measurable reduction in symptoms, as demonstrated by a 2009 study (Faber Taylor et al.); isolated exposures to greenspace also appear to provide a lingering attenuation of symptoms substantial enough for parents to take notice (Faber Taylor et al., 2001; Kuo & Faber Taylor, 2004). Furthermore, findings from a previous, smaller study linked routine exposures to greenspace to ongoing milder symptoms (Faber Taylor et al., 2001). The evidence to date suggests that exposure to greenspace may be effective for both short- and long-term reductions in symptom severity and may be generalisable to a wide range of children. Furthermore, the evidence lends credence to the possibility that children with ADHD—more than 4 million in the United States alone—may find regular doses of greenspace to be a valuable supplement to medication and behavioral treatments. As a potential treatment routine, exposures to greenspace seem feasible and even preferable for families. Administering doses of greenspace by spending time in natural settings daily or weekly is relatively easy, inexpensive, and readily accessible for most families particularly when compared to other typical leisure activities such as visiting museums, or participating in organised sports, dance or music lessons. Furthermore, for managing symptoms in the evening, contact with greenspace would be preferable to an evening dose of stimulant medication, which can disrupt sleep (AACAP & APA, n.d.; AAP, 2001; Wolraich et al., 2007).

We should consider pursuing exposure to greenspace as a viable option in the toolkit of treatments for children with ADHD, given its demonstrated effectiveness and practicability. To do so we will need to apply randomised clinical trials; in particular, trials that plot the dose–response curve and that delineate which features of greenspaces best reduce attention-deficit symptoms, especially in hyperactive children. Further, our findings add to the growing body of evidence suggesting that for all children, time in greenspace fosters healthy child development in myriad ways. Thus, facilitating children's everyday contact with greenspace should be a priority as we design our communities and families plan their daily routines.

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