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ORIGINAL PAPER

The Effectiveness of Mindfulness Training on Behavioral Problems and Attentional Functioning in Adolescents with ADHD

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Abstract The effectiveness of an 8-week mindfulness training for adolescents aged 11–15 years with ADHD and parallel Mindful Parenting training for their parents was evaluated, using questionnaires as well as computerized attention tests. Adolescents ($N = 10$), their parents ($N = 19$) and tutors ($N = 7$) completed measurements before, immediately after, 8 weeks after and 16 weeks after training. Adolescents reported on their attention and behavioral problems and mindful awareness, and were administered two computerized sustained attention tasks. Parents as well as tutors reported on adolescents' attention and behavioral problems and executive functioning. Parents further reported on their own parenting, parenting stress and mindful awareness. Both the mindfulness training for the adolescents and their parents was delivered in group format. First, after mindfulness training, adolescents' attention and behavior problems reduced, while their executive functioning improved, as indicated by self-report measures as well as by father and teacher report. Second, improvements in adolescent' actual performance on attention tests were found after mindfulness training. Moreover, fathers, but not mothers, reported reduced parenting stress. Mothers reported reduced overreactive parenting, whereas fathers reported an increase. No effect on mindful awareness of adolescents or parents was found. Effects of mindfulness training became stronger at 8-week follow-up, but waned at 16-week follow-up. Our study adds to the emerging body of evidence indicating that mindfulness training for adolescents with ADHD (and their parents) is an effective approach, but maintenance strategies need to be developed in order for this approach to be effective in the longer term.

Keywords Attention-deficit Hyperactivity disorder ·
Mindfulness · Mindful Parenting · Adolescents · Treatment

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common neuropsychiatric disorders in childhood, and often persists into adulthood (Barkley 1998; Wender 2000). Deficits in ADHD can be described on a behavioral, neuropsychological and brain level. On a behavioral level, ADHD is characterized by age-inappropriate symptoms of attention, hyperactivity and impulsive behavior (American Psychiatric Association 2000). On a neuropsychological level, ADHD is associated with poorer performance on tasks tapping into executive functions (EF), such as response inhibition, attention and working memory (Rubia 2010; Rubia et al. 2001; Seidman 2006). On a brain level, children with ADHD have been found to have reduced size and function of fronto-parietal and fronto-striatal neural networks (Cubillo et al. 2011; Krain and Castellanos 2006; Rubia 2010), during performance on inhibition and attention tasks (Rubia et al. 2005). Children with ADHD often experience impairments in academic as well as social domains. Since ADHD is highly heritable, parents of

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children with ADHD may also show ADHD symptoms (Thapar et al. 2007). Recent studies on the interaction between genes and the environment indicate that inconsistent parenting increases the susceptibility to ADHD in children who are genetically at risk for ADHD (Martel et al. 2010). Moreover, parenting has been shown to be more inconsistent in parents of children with ADHD (Harvey et al. 2001) and in parents with ADHD (symptoms) (Harvey et al. 2003; Murray and Johnston 2006).

Behavioral treatments and medication have been shown to be effective in the treatment of ADHD, but have several limitations (Van der Oord et al. 2008). First, although behavioral parent management training has been shown to be effective, a diagnosis of ADHD in parents predicts non-response to this treatment (Sonuga-Barke et al. 2002; Van den Hoofdakker et al. 2010). Moreover, parent management training has been investigated predominantly in pre-adolescent children, and effects for adolescents seem lower (Barkley 2004; Chronis et al. 2004). Second, cognitive behavioral therapy (CBT) for children with ADHD has only limited long term effects, and generalization of the learned skills is often low (Chambles and Ollendick 2001; Pelham and Fabiano 2008). Consistent with these findings, no effects of CBT were found in a study of adolescents with ADHD (Morris 1993). Third, medication (mostly stimulants) works only short-term, is often accompanied by side-effects, and treatment fidelity is often low (Schachter et al. 2001). Moreover, medication adherence decreases during adolescence (Wolraich et al. 2005). The annual societal costs of illness (COI) for ADHD in children and adolescents in the USA are roughly estimated to be around 42.5 billion dollars (Pelham et al. 2007) which is enormous, compared to for instance the annual costs for a somatic disorder like asthma of around 4 billion dollars (Stock et al. 2005). Further, the risk for suicide in youngsters with ADHD is nearly three times higher than in controls (James et al. 2004). These findings indicate there is a need to develop and investigate new and effective treatments for adolescents with ADHD. Therefore, we examined the effectiveness of a novel treatment approach, mindfulness training, for adolescents with ADHD and their parents.

Mindfulness is a form of attention or meditation training, based on Buddhist tradition and Western knowledge of psychology, in which awareness of the present moment and non-judgmental observation is increased, whereas automatic responding is reduced (Kabat-Zinn 2003). Mindfulness-based interventions have been shown to be effective in adults who suffer from depression, stress, pain and illness (Bear 2003; Hofmann et al. 2010). Two recent reviews show that there is a growing body of evidence on the effectiveness of mindfulness training for children and adolescents (Black et al. 2009; Burke 2009). However,

effect sizes are smaller than in adult samples, and studies are often conducted with clinically diverse populations (Black et al. 2009; Burke 2009). The answer to why mindfulness training may be an effective treatment for ADHD, lies in the three levels of functioning mentioned earlier with regard to ADHD. On a behavioral level, mindfulness meditation focuses on increasing the ability to control attention, and on reducing automatic responses (Teasdale et al. 1995). On a neuropsychological level, research shows that mindfulness meditation enhances performance on tasks measuring EF, such as attention, working memory and cognitive control (Heeren and Philippot 2011; Semple 2010). And at brain level, evidence is found for changes in activity in the fronto-striatal circuits after mindfulness or meditation training (Chiesa and Serretti 2010; Kilpatrick et al. 2011; Tang et al. 2010). These results suggest that mindfulness training may be relevant as an attention training for adolescents with ADHD.

To our knowledge, there are only few studies investigating the effects of mindfulness or meditation training in children or adolescents with ADHD (Grosswald et al. 2008; Zylowksa et al. 2008). Grosswald et al. (2008) for example found reduced attention and total problems after transcendental meditation in 11–14 year old children with ADHD, using a non-controlled pre-post design. Zylowksa et al. (2008) also found that self-reported ADHD symptoms and performance on several neurocognitive attention tasks improved after mindfulness training in a mixed group of adults and adolescents. However, this study also used a non-controlled pre-post design and results for the seven participating adolescents were not reported separately.

The abovementioned studies only included children and adolescents in the treatment. However, including parents in treatment may be beneficial, because parents (of children) with ADHD (Harvey et al. 2001; Murray and Johnston 2006) may show less consistent parenting, and inconsistent parenting increases the susceptibility to ADHD in children who are genetically at risk for ADHD (Martel et al. 2010). That is, parents of children with ADHD are likely to experience more stress (Deault 2010), which may lead to becoming less patient, paying more attention to disruptive behavior and acting more reactive (Bögels et al. 2010; Dumas 2005). This 'parental overreactivity' is predictive of externalizing behavior of the child (Johnston et al. 2002). In addition, generalization of the learned skills outside the treatment setting may be enhanced by including parents (Bögels et al. 2008). In Mindful Parenting (MP) training, parents learn to pay attention to their children and their parenting in a non-judgmental way, to increase their awareness of the present moment with their child, and to reduce automatic (negative) reactions to their child (Bögels et al. 2010; Kabat-Zinn and Kabat-Zinn 1997). Also, participants learn to take care of themselves and bring calm

into their family. A few studies have investigated the effects of mindfulness or meditation training for children and adolescents with ADHD and mindfulness or meditation training for parents and show promising results (Bögels et al. 2008; Harrison et al. 2004; Singh et al. 2010; van der Oord et al. 2011). Bögels et al. (2008) found strong improvements on externalizing problems and sustained attention after mindfulness training for adolescents with behavior disorders (ADHD, Oppositional Defiant Disorders [ODD], and Autism Spectrum Disorders [ASD]) paralleled by MP for their parents. However, due to the heterogeneity in DSM-IV diagnoses in this group of adolescents, the training was not specifically aimed at improving ADHD symptoms, and it is not clear how adolescents with ADHD specifically benefited from this training. A recent pilot study of our research group on mindfulness training for 8–12 year old children with ADHD ($N = 18$) and MP for their parents showed promising results using a waitlist-pre-post-follow-up design (van der Oord et al. 2011). ADHD symptoms of children as well as parents reduced significantly, as reported by parents. Effect sizes (ES) were medium to large for children's improvements and small for parents improvement, and effects were maintained at 8-week follow-up. Also, parenting stress (medium ES) and parental overreactivity (large ES) showed significant reductions. Harrison et al. (2004) investigated the effects of a 6-week Sahaja yoga meditation training for 4–12 year old children and their parents in a pre-post design. Parent-reported ADHD symptoms, anxiety and self-esteem of the children improved significantly, as well as child-reported self-esteem. Also, parent–child relationships improved, mainly due to a reduction in conflict. Singh et al. (2010) found compliance to increase in two children with ADHD, after mindfulness training for their mothers, and consecutive mindfulness training for the children. These findings indicate that including parents in the treatment may increase the effects of mindfulness training for children and adolescents with ADHD.

Summarized, previous studies have shown preliminary but promising results. However, study samples were small, were often conducted with pre-adolescent children, were mostly lacking teacher reports, did not include objective neuropsychological measures of attention, and/or did not examine long term effects of mindfulness training. Therefore, in our study, we investigated the effectiveness of mindfulness training for adolescents with ADHD and MP for their parents, using a non-controlled pre-post-follow-up design. Adolescent functioning was assessed using adolescent, parent and tutor reports of attention and behavioral problems, as well as neurocognitive computerized tasks measuring attention and impulsivity. We expected symptoms and behavioral problems to reduce after mindfulness training, and task performance to improve.

Method

Participants, Procedure and Design

Ten adolescents (five boys and five girls) with the DSM-IV (APA 2000) classification ADHD (five with combined, four with inattentive and one with hyperactive/impulsive type) and their parents were offered mindfulness training and MP training respectively. Participants were referred to an academic treatment centre for parents and children in the Netherlands for classification and/or treatment of ADHD. Five adolescents participated with their mother, four with their father and one with both parents. All parents (both participating and non-participating in the training) were asked to participate in this study and they all agreed and signed informed consent, except for 1 father, who was living abroad. All participating mothers and fathers were biological parents and were living in the same household as the participating adolescent. The age of the adolescents ranged from 11 to 15 years, with a mean age of 13.4. One adolescent attended the last grade of primary school and nine adolescents attended high school (two attended pre-vocational secondary education, five attended higher secondary general education, and two attended pre-university education). The high-school tutors and the primary school teacher (referred to as 'tutors' from here on) of the adolescents were asked to participate in this study and they all agreed and signed informed consent. One of the adolescents used stimulant medication (Methylphenidate) at the beginning of the study. Medication for this adolescent was kept stable during the training. Two adolescents started medication after the posttest and were excluded from the follow-up analyses.

A non-experimental design was used. One week before treatment all participants were assessed for a pretest. Immediately after the 8-week treatment, participants received a posttest. Two follow-up measurements were planned, respectively 8 and 16 weeks after posttest.

Treatment

Adolescent Training. The treatment is conducted in groups of four to six adolescents, and consists of 8-weekly 1.5 h sessions. Eight weeks after the last session, adolescents and parents follow a joined booster session. The treatment is based on a mindfulness program developed for children with ADHD and their parents (Bögels et al. 2008; van der Oord et al. 2011) and was also inspired by the Mindfulness in Schools Project (Huppert and Johnson 2010). To enhance compliance, adolescents and their parents met with the trainers before the start of the intervention, to discuss the problems they face, difficulties in parenting, the potential benefits of meditation, expectations of the

training, motivation, and the necessity of doing homework. To increase the adolescents' commitment to training and home practice, a reward system was used (see Bögels et al. 2008; van der Oord et al. 2011).

Adolescents learn to focus and enhance their attention, awareness and self-control by doing mindfulness exercises during the training and as homework assignments. Regular mindfulness exercises (e.g., sitting meditation, body scan, breathing space) were alternated with exercises addressing the specific issues of adolescents with ADHD. That is, awareness of one's distractibility, impulsivity, and hyperactivity was enhanced, and the breathing space practiced on such occasions. Examples of such exercises are a distraction exercise, in which adolescents practice a breathing space while being distracted by the other participants, and a fixation exercise, in which adolescents fixate on a single point (drawn on a flap-over) or on bubbles blown by one of the trainers, to become aware of distractibility in different situations (static versus dynamic). Also, they are taught to apply mindfulness in difficult and stressful situations, such as having conflicts with a parent, teacher or peer. The breathing space was practiced during role-play of such conflict situations. By enhancing their attention and awareness it is expected that externalizing behavior will be reduced. In addition, adolescents are taught how to apply mindfulness when doing their homework for school. The training was adjusted to the specific needs of adolescents with ADHD. For example, the training was given in a stimulus-free environment. Also, sessions were highly structured: the outline of the session was always visible for adolescents, and was kept constant in structure (e.g. always starting and ending with a short breathing meditation). Compliance during exercises was enhanced by letting one trainer provide the exercise, while the other trainer checked compliance. Good compliance was rewarded during and after the exercise. After each session, adolescents received session handouts describing theme, instructions for practice, and homework completion forms.

Mindful Parenting Training. Parallel to the mindfulness treatment of the adolescents, the parents received an 8-week MP training (Bögels et al. 2008; van der Oord et al. 2011). At the beginning of the course, parents received a CD with mindfulness exercises for home practice. Parents learn in MP to (1) be deliberately and fully present in the here and now with their adolescent child in a non-judgmental way; (2) take care of themselves, as an important basis for parenting; (3) accept difficulties of their adolescent; and (4) respond rather than react to difficult behavior of the adolescent child. The training is further modified from the manual described by Bögels et al. (2008, 2010) to meet the specific issues of parenting of adolescents with ADHD. That is, awareness of one's automatic reaction to the adolescents' (ADHD-related) oppositional, inattentive,

and hyperactive behavior was enhanced, and the breathing space practiced on such occasions, to change parental automatic, inattentive, impulsive or judgmental reactions into more intended, mindful responses. Also, given the higher chance that participating parents suffered from ADHD-like symptoms themselves, mindfulness and Mindful Parenting exercises and the subsequent inquiry were tailored towards the application to their own restlessness, inattentiveness, impulsivity, lack of structure etc. The extra strains that an adolescent with ADHD can put on parenting and on family functioning, and how mindfulness meditation can help, were also addressed. For example, parents of ADHD children (or partners) may need meditation to find their own calm in the middle of a more busy and chaotic family. Another example: adolescents strive for autonomy but an adolescent with ADHD may need more (parental) guidance, but also need to sense that parents trust his or her growing autonomy. MP may help parents become aware of this paradox and find a balance between close monitoring and support and letting go. The importance for the parents to practice daily, in order for them to embody mindfulness, to guide their child, to function as a role model, as well as for their own well-being and possible ADHD symptoms, was emphasized. After each session, parents received session handouts describing theme, instructions for practice, and homework completion forms.

Both the adolescent and the parent training were delivered by experienced cognitive-behavior therapists who also were experienced mindfulness practitioners and mindfulness trainers. During the training period, therapists met on a weekly basis for supervision to discuss the group process and the individual clients and to ensure treatment integrity.

Measures

Behavioral Symptoms

Adolescents, parents, and tutors reported on adolescents' symptoms the Youth Self Report (YSR), the Child Behavior Checklist (CBCL), and the Teacher Report Form (TRF), respectively (Achenbach 1991; Verhulst et al. 1996, 1997a, b). The YSR consists of 112 items, whereas the CBCL and TRF consist of 113 items, all rated on a 3-point scale (0 = not true to 2 = often true). Eight syndrome scales can be calculated: Anxious/Depressed, Withdrawn/Depressed, Somatic Complaints, Social Problems, Thought Problems, Attention Problems, Rule-Breaking Behavior and Aggressive Behavior. From these eight scales, three broadband scales can be calculated representing Internalizing, Externalizing and Total problems. In our study, the scale Attention problems, as well as the broadband scales Externalizing problems and Internalizing problems were used. Internal consistency for Attention, Externalizing and

Internalizing problems ranges from α = .80 to .95 for the YSR, CBCL and TRF, and test–retest reliability ranges from r = .82 to .94 (Achenbach and Rescorla 2001). In this study, internal consistencies ranged from α = .63 to .95.

Executive Functioning

Parents and tutors rated adolescents' executive functioning on the Behavior Rating Inventory of Executive Function (BRIEF; (Goia et al. 2000; Smidts 2009). This 86-item questionnaire consists of two broad indexes (Behavioral Regulation and Meta-cognition). An example item of Behavioral Regulation is: *"Is too wild or unruly"*, and of Metacognition is: *"Has difficulties with planning activities in order to obtain a goal"*. The BRIEF has appropriate psychometric properties including internal consistency of the two indexes ranging from α = .93 to .97 for parent and teacher reports and test–retest reliability ranging from r = .74 to .95. Internal consistency ranged between α = .69 and .95 in our study.

Mindful Awareness

Adolescents' as well as parents' self reported awareness was measured with the Mindful Attention and Awareness Scale (MAAS) (Brown and Ryan 2003; Schroevers et al. 2008). The 15-item scale measures the extent to which a person functions on "automatic pilot", meaning not being aware of the present experience. Items are rated on a 6-point likert scale (1 = almost always to 6 = almost never). An example item is "*I tend to walk quickly where I am going without paying attention to what I experience on the way*". The MAAS has good test–retest reliability (intra class correlation = .81), and good internal consistency (α ranges from .82 to .87 in different samples) (Brown and Ryan 2003; MacKillop and Anderson 2007). In our study we found an internal consistency of .90.

Parenting Stress

The Parenting Stress Index—short version (PSI) assesses the extent to which parents experience stress due to various sources within the context of raising a child using 25 items on a 6-point Likert scale (totally disagree–totally agree) (Abadin 1983; De Brock et al. 1992). An example item is '*I have more problems with raising my child than I had expected*'. The internal consistency ranges between α = .92 and .95 in different samples of fathers and mothers. In our study we found an internal consistency of α = .95 for both fathers and mothers.

Parenting Style

The 30-item Parenting Scale (PS) assesses dysfunctional discipline styles using three scales: Laxness, Overreactivity and Verbosity (Arnold et al. 1993). Parents rated items on a 7-point scale presented between two counterparts, for example '*When my child misbehaves, I raise my voice and yell*' and its effective counterpart '*…I speak to my child calmly*'. The PS has adequate test–retest reliability (r = .84) and internal consistency (Laxness .83, Overreactivity .82, and Verbosity, .63). Construct validity was supported by the relationship with observed parenting behaviors (Arnold et al. 1993). Only the subscale Overreactivity was used in this study. Internal consistency was α = .93 for both fathers and mothers in our study. Higher scores reflect less effective discipline styles.

Fatigue

Adolescents completed the 7-item Flinders Fatigue Scale (FFS) to assess daytime fatigue associated with insomnia (Gradisar et al. 2007) using a 5-point scale (0 = not at all, 4 = extremely), except for item 5 which consists of a 7-item checklist. The items tap into how problematic fatigue is, the consequences of fatigue, frequency, severity, etc. An example item is: "*[over the last 2 weeks] was fatigue a problem for you?*". The internal consistency of the scale ranges between α = .86 and .91 in different samples (Gradisar et al. 2007), and was α = .84 in our study.

Happiness

Adolescents completed the 4-item Subjective Happiness Scale (SHS; (Lyubomirsky and Lepper 1999) to assess feelings of happiness. Items are scored on a 7-point scale presented between two counterparts, for example '*Compared to most of my peers, I consider myself less happy*' and its counterpart '*…I consider myself more happy*'. The internal consistency of the scale ranges between α = .79 and .94 in different samples, and was α = .90 in our study.

Computerized Test of Attention

Adolescents performed three computerized tasks, a baseline speed task and two sustained attention tasks, from the Amsterdam Neuropsychological Tasks (ANT, De Sonneville 2005). Multiple studies have shown that the ANT is a sensitive and valid tool (Gunther et al. 2009; Marchetta et al. 2008).

Task 1: Baseline Speed (BS) measures reaction speed for both hands (starting with the non-preferential hand). During this task a cross is displayed in the middle of the screen.

When the cross changes into a square, participants have to press the mouse button as fast as possible. At the press of the button, the square changes back into a cross, after which participants have to wait for the next square. This sequence repeats itself for 32 trials for each hand, with a random interval between response and stimulus. The outcome measure is the mean Reaction Time (RT) over trails for each hand.

Task 2: Sustained Attention Dots (*SAD*) is used to measure visual sustained attention. In this task, dots are presented in a square on the computer screen. The number of dots (three, four or five dots) presented varies between trials, which are randomly presented in 50 series of 12 trials, with a balanced presentation of four signals of each type. The participant has to press the right mouse button with the preferential hand when four dots are shown (target). The left mouse button is to be pressed when three or five dots are presented (non-target). The 1-week test–retest reliability for this task was $r = .82$ in a sample of children and adolescents with treated phenylketonuria (De Sonneville 2005).

Task 3: Sustained Attention Auditory (*SAA*) During this auditory sustained attention task, three different tones are presented in random order. Participants only have to press the mouse button (with the preferential hand) when they hear the highest tone of all three. The three tones are presented during 361 trials with a balanced presentation.

Due to the length of the tasks, both SAD and SAA require sustained attention, and provide measures of attention as well as impulsivity. The outcome measures used for this study are mean RT, number of Misses (no or incorrect response to a target) and number of False alarms (incorrect response to a non-target). A high number of Misses is considered indicative of poorer attentional functioning. A high number of False alarms is considered to indicate more problems with impulsivity.

Statistical Analyses

Changes from pretest to posttest and pretest to follow-up were analyzed by means of paired t tests (e.g., posttest minus pretest). Since the probability of false positive findings increases in small samples, 2-sided p values were considered. In the case of borderline significant effects ($p < .10$), the 95% confidence interval (95% CI) of the mean difference will be reported (Hackshaw and Kirkwood 2011) to prevent the dismissal of clinically meaningful results due to a small sample. Effect sizes of change (Cohen's d) were calculated by the mean of the difference (e.g., posttest minus pretest) divided by the standard deviation (SD) of these differences (Cohen 1988). Effect sizes <.4 are considered small, .4–.8 medium and >.8 large.

Results

Missing Values

At pre- and posttest, data was complete for adolescents ($N = 10$) and mothers ($N = 10$). One father lived abroad, leaving $N = 9$ fathers. Only $N = 7$ tutors returned the posttest measurement. Since two adolescents started with medication after the posttest, their data was excluded from follow-up analyses, leaving $N = 8$ adolescents, $N = 8$ mothers, and $N = 7$ fathers at 8-week follow-up. At 8- and 16-week follow-up, the report of tutors was not included in the analyses, due to transition of their students to the next grade after posttest. At 16-week follow-up, due to drop-out of most parents, data for fathers and mothers was not analyzed, and only $N = 6$ from the 8 adolescents completed measurement, due to drop-out.

Questionnaires

Descriptive values and results from independent t tests for self-report measures are presented in Table 1.

Behavioral Symptoms (YSR, CBCL, TRF)

Attention. A borderline significant reduction in attention problems was reported after training by fathers (95% CI −5.35 to .46, $p = .09$). Adolescents, mothers and tutors reported no significant reduction. At 8-week follow-up, fathers as well as adolescents reported a significant reduction in attention problems, but mothers did not. At 16-week follow-up, adolescents reported no significant reduction in attention problems.

Externalizing. Directly after mindfulness training, externalizing problems reduced significantly as reported by fathers, but not by adolescents, mothers or tutors. At 8-week follow-up, the reduction reported by fathers was maintained and adolescents reported a borderline significant reduction as well (95% CI −7.09 to .34, $p = .07$). No significant reduction was reported by mothers. At 16-week follow-up, adolescents reported no significant reduction.

Internalizing. Fathers reported a borderline significant reduction in internalizing problems after training (95% CI −8.09 to .09, $p = .05$). No significant reduction was reported by adolescents, mothers or tutors. At 8-week follow-up, the borderline significant reduction reported was maintained in fathers (95% CI −13.16 to .59, $p = .07$). Again, adolescents and mothers reported no significant reduction. At 16-week follow-up, adolescents reported a borderline significant reduction in internalizing problems (95% CI −7.06 to .073, $p = .09$).

Table 1 Effects of mindfulness training on self report measures from pretest to posttest, 8-week follow-up (FU1) and 16-week follow-up (FU2)

	Pretest		Posttest		FU1		FU2		Pre- versus posttest		Pretest versus FU1		Pretest versus FU2	
	M	SD	M	SD	M	SD	M	SD	t (df)	ES	t (df)	ES	t (df)	ES
YSR/CBCL/TRF														
Attention														
Adolescent	9.7	4.2	8.0	2.7	6.8	2.2	6.3	2.6	−1.8 (9)	0.5	−3.1 (7)	0.9*	−1.9 (5)	1.0
Mother	9.6	3.2	9.3	3.5	8.5	4.0			−0.7 (9)	0.1	−1.2 (7)	0.3		
Father	9.4	3.0	7.0	4.7	5.4	2.3			−1.9 (8)	0.6†	−4.9 (6)	1.5**		
Tutor	18.7	17.2	14.0	12.2					−1.7 (6)	0.3				
Externalizing														
Adolescent	14.6	8.8	15.6	9.1	10.8	7.0	7.8	5.8	0.9 (9)	0.1	−2.2 (7)	0.5†	−2.1 (5)	0.9†
Mother	12.1	8.1	13.8	10.3	11.1	7.1			1.0 (9)	0.2	−0.4 (7)	0.1		
Father	10.3	9.4	8.4	9.3	7.3	10.3			−2.4 (8)	0.2*	−3.7 (6)	0.3*		
Tutor	8.6	8.4	7.0	7.9					−1.1 (6)	0.2				
Internalizing														
Adolescent	9.2	9.2	8.3	9.6	7.6	5.9	4.0	3.5	−0.6 (9)	0.1	−1.3 (7)	0.2	−1.8 (5)	0.7
Mother	10.8	7.0	10.0	8.3	10.9	8.4			−0.7 (9)	0.1	−0.6 (7)	0.0		
Father	11.0	8.8	7.0	9.2	6.9	9.3			−2.6 (8)	0.4†	−2.2 (6)	0.5†		
Tutor	5.9	4.4	4.9	5.4					−0.7 (6)	0.2				
BRIEF														
Metacognition														
Mother	99.0	9.8	102.0	13.6	99.3	10.8			0.9 (9)	0.3	0.1 (7)	0.0		
Father	98.8	7.1	90.0	10.9	86.0	7.5			−2.0 (8)	1.0†	−3.6 (6)	1.8*		
Tutor	84.7	33.7	77.4	26.5					−1.5 (6)	0.2				
Behavioral regulation														
Mother	49.4	8.4	50.9	10.9	48.4	7.8			0.9 (9)	0.2	−0.1 (7)	0.1		
Father	45.3	12.0	43.7	13.8	38.6	9.1			−0.5 (8)	0.1	−2.8 (6)	0.6*		
Tutor	47.7	16.0	41.4	10.5					−2.3 (6)	0.5†				
MAAS														
Adolescent	59.7	23.5	61.7	19.5	58.4	22.9	69.3	9.3	0.3 (9)	0.1	0.0 (7)	0.1	1.3 (5)	0.5
Mother	55.7	13.4	60.3	14.2	57.1	16.5			0.8 (9)	0.3	0.3 (7)	0.1		
Father	64.3	9.7	61.9	15.4	60.7	15.9			−0.4 (8)	0.2	−1.0 (6)	0.3		
Parenting stress														
Mother	64.1	17.4	73.1	20.6	67.4	19.4			1.5 (9)	0.5	−0.1 (7)	0.2		
Father	73.8	27.8	54.1	28.7	46.1	24.0			−4.2 (8)	0.7**	−4.7 (6)	1.1**		
PS overreactivity														
Mother	42.0	11.9	30.8	9.5	35.0	10.1			2.2 (9)	1.0*	1.8 (7)	0.6		
Father	34.0	12.1	44.7	12.8	30.0	14.3			−3.6 (8)	0.9*	.5 (6)	0.3		
Fatigue														
Adolescent	12.7	5.6	12.9	6.9	11.9	3.6	13.0	4.4	0.3 (9)	0.0	−1.6 (7)	0.2	0.5 (5)	0.1
Happiness														
Adolescent	16.9	3.4	15.2	4.1	15.0	5.2	16.2	2.3	−0.9 (9)	0.5	−0.6 (7)	0.4	−1.2 (5)	0.2

M means, *SD* standard deviations, *t* t-values, *df* degrees of freedom and *ES* effect sizes (N = 6–10 adolescents, N = 8–10 mothers, N = 7–9 fathers, N = 7 tutors)

YSR Youth Self Report, *CBCL* Child Behavior Checklist, *TRF* Teacher Report Form, *BRIEF* Behavior Rating Inventory of Executive Functioning, *MAAS* Mindful Attention and Awareness Scale, *PS* Parenting Scale

Two-sided *p* values † *p* < .10; * *p* < .05; ** *p* < .01

Table 2 Effects of mindfulness training on computerized attention tests from pretest to posttest, 8-week follow-up (FU1) and 16-week follow-up (FU2)

	Pretest		Posttest		FU1		FU2		Pre-versus posttest		Pretest versus FU1		Pretest versus FU2	
	M	SD	M	SD	M	SD	M	SD	T (df)	ES	t (df)	ES	t (df)	ES
Baseline Speed														
Speed	284.7	25.3	291.0	27.5	286.9	41.1	312.3	48.1	1.1 (9)	0.2	0.5 (6)	0.1	1.7 (5)	0.7
SAD														
Speed	750.1	110.8	647.7	118.4	702.4	212.8	681.0	183.7	−5.5 (9)	0.9**	−0.9 (6)	0.3	−1.1 (5)	0.5
Misses	38.2	7.8	35.4	7.8	26.4	18.5	30.3	21.1	−1.0 (9)	0.4	−1.0 (6)	0.8	−0.3 (5)	0.5
False alarms	5.5	2.1	5.5	1.8	4.6	3.1	5.2	3.3	0.0 (9)	0.0	−0.5 (6)	0.3	−0.3 (5)	0.1
SAA														
Speed	574.8	118.4	562.8	149.7	575.7	143.6	593.0	153.1	−0.2 (9)	0.1	0.6 (6)	0.0	1.7 (5)	0.1
Misses	11.7	8.1	9.8	8.8	5.9	5.3	8.8	7.5	−1.0 (9)	0.2	−2.6 (6)	0.8*	−1.2 (5)	0.4
False alarms	8.3	10.1	3.9	8.0	3.0	4.5	2.8	3.3	−2.5 (9)	0.5*	−2.3 (6)	0.7†	−2.4 (5)	0.7†

M Means, *SD* standard deviations, *t* t-values, *df* degrees of freedom and *ES* effect sizes (*N* = 6–10 adolescents)

SAD Sustained Attention Dots, *SAA* Sustained Attention Auditory

Two-sided *p* values † *p* < .10; * *p* < .05; ** *p* < .01

Executive Functioning (BRIEF)

Metacognition. After training, metacognitive problems reduced borderline significantly as reported by tutors (95% CI −18.94 to 1.39, *p* = .08), but not by fathers or mothers. At 8-week follow-up, fathers, but not mothers, reported a significant reduction in meta-cognitive problems.

Behavioral Regulation. Problems in behavioral regulation improved borderline significantly after training according to fathers (95% CI −12.97 to .40, *p* = .06), but not according to mothers and tutors. At 8-week follow-up, the improvement reported by fathers reached significance. Again, mothers reported no improvement.

Mindful Awareness and Attention (MAAS)

Neither adolescents, fathers, nor mothers reported a change in their self-rated mindful awareness and attention after training, or at 8-week follow-up. Adolescents also did not report a significant change in mindful awareness at 16-week follow-up.

Parenting Stress (PSI) and Parental Overreactivity (PS)

A significant reduction in parenting stress after training was reported by fathers, but not mothers. Mothers reported a significant reduction in parental overreactivity, whereas fathers reported a significant increase. The reduction in parenting stress reported by fathers was maintained at 8-week follow-up. Mothers did not report change in stress level. Changes in parental overreactivity were not maintained at 8-week follow-up.

Fatique (FFS) and Feelings of Happiness (SHS)

Adolescents reported no significant change in daytime fatigue or feelings of happiness after training, nor at 8- and 16-week follow-up.

Computerized Attention Tests (ANT)

Descriptive values and results from independent *t* tests for computerized attention tests are presented in Table 2.

Baseline Speed

Adolescents showed no improvement on baseline reaction speed after training, at 8-week follow-up, nor at 16-week follow-up.

Sustained Attention Dots

After training, adolescents showed a significant reduction in reaction speed, but no changes were found in the number of misses or false alarms. At 8-week and 16-week follow-up, the improvement in reaction speed was not maintained and again, no significant changes in the number of misses and false alarms were found.

Sustained Attention Auditory

After training, adolescents showed no significant improvement on reaction speed or the number of misses. However, the number of false alarms reduced significantly. At 8-week follow-up, reaction speed did not improve significantly. The reduction in false alarms was only borderline significant

(95% CI −13.33 to .47, $p = .06$), whereas the number of misses reduced significantly. At 16-week follow-up, a borderline significant reduction in the number of false alarms was maintained (95% CI −16.96 to .62, $p = .06$), but no significant reduction was found in the number of misses or reaction speed.

Discussion

This study evaluated the direct, middle-term and longer-term effects of mindfulness training for adolescents with ADHD and Minful Parenting for their parents, using self-report questionnaires with multiple informants as well as objective neurocognitive measures of attentional functioning.

Directly after training, adolescents' externalizing, internalizing and attention problems reduced, and executive functioning improved on self-report measures. Reported improvements were confirmed by enhanced performance on the computerized attention tests. Effect sizes ranged from small to large. At 8-week follow-up, reductions in problem behaviors and improvements in executive functioning were maintained and became stronger. Again, improvements were confirmed by enhanced performance on computerized attention tests. Most effects were of medium to large size. At 16-week follow-up, reductions in problems behaviors diminished, as did the improved performance on computerized attention tests. Self-reported mindful awareness of adolescents and parents did not change at any time, and neither did adolescent's fatigue or feelings of happiness. A direct as well as a longer-term reduction of parenting stress was found in fathers. A reduction in parental overreactivity was found in mothers, whereas fathers reported an increase.

The vast majority of results point to improvement, although there are some noticeable findings that need further consideration. First, all informants reported improvements in adolescent functioning at some point, except for mothers. This is especially striking since mothers reported no improvement on any of these measures while fathers reported improvement on every measure. Although discrepant ratings are common between informants (Langberg et al. 2010), informants from the same setting (e.g., fathers and mothers) rate children more similar than informants from different setting (e.g. fathers and teachers), which stresses the importance of independent reports from parents and teachers on ADHD symptoms in the home and school setting respectively (de Nijs et al. 2004). In a meta-analysis (Duhig et al. 2000), a moderate level of mother-father agreement on ratings of child behavioral problems was found ($r = .61$). In our study, agreement between parents

on behavioral problems ranged from $r = .47$ to .78. One possible explanation for this difference between fathers and mothers in report of adolescent's behaviors may be found in the stress levels of parents. Parental stress has been shown to moderate parent's ratings of child disruptive behavior. That is, when parental stress is low, fathers rate children's ADHD and externalizing symptoms lower than mothers, but when stress levels are high, fathers rate children's symptoms higher than mothers (Langberg et al. 2010). Perhaps the fact that fathers did report reduced parenting stress after mindfulness training, and not mothers, may have influenced their perception of improvement in the adolescents' behaviors. Or, alternatively or in addition, fathers' perceived reduction in adolescents' externalizing behavior may have affected their parental stress. Inspection of the correlations between difference scores in parenting stress and difference scores in adolescent symptoms revealed that pre- to posttest reductions in parental stress level were only significantly related to improvement in adolescent's attention problems ($r = .68$, 2-sided $p < .05$) for fathers, but significantly related to improvement in attention problems ($r = .64$, $p < .05$), as well as behavioral regulation ($r = .75$, $p < .05$) and metacognition ($r = .83$, $p < .01$) reported by mothers. Reductions in parental stress from pretest to 8-week follow-up was related to improved attention ($r = .70$, $p < .10$), internalizing ($r = .77$, $p < .05$), behavioral regulation ($r = .75$, $p < .05$) and metacognition ($r = .75$, $p < .05$) as reported by mothers, but not by fathers. These results suggest that improvement reported by fathers was not merely a subjective effect, as a result of the reduction of stress after the mindfulness training. In addition, the objective findings from the computerized tests and the tutor-reported improvements indicate that reduced stress cannot account for all effects.

In addition, an interesting result is that all fathers reported a significant reduction in stress levels after treatment, participating fathers (posttest $t(6) = 3.57$, $p < .01$; follow-up $t(6) = 4.86$, $p < .01$) as well as non-participating fathers (posttest $t(6) = 2.95$, $p < .05$; follow-up $t(6) = 2.81$, $p < .05$), indicating that the mindfulness training has indirect additional benefits, at least for fathers.

A second explanation for the differences in change reported by fathers and mothers may be that fathers report higher stress levels or adolescent problems than mothers at pretest, leaving more room for improvement. However, paired sample t tests revealed that, at pretest, fathers and mothers did not differ significantly in reports of parenting stress, or any of the adolescent symptoms or problem behaviors. Similar parenting stress for fathers and mothers had also been found in earlier studies of children with ADHD (Baker 1994) and children without ADHD (Deater-Deckard and Scarr 1996).

Another factor that could be related to the differential findings for mothers and fathers may be found in the father-mother ratio of the parent-group. Compared to the normal ratio of fathers versus mothers in child therapy, ranging between 1:2 and 1:3 (Lamb 2010), the proportion of fathers participating in our training was high (1:1). It is possible that fathers were particularly motivated to participate. In fact, most participating fathers indicated during the intake interview before training that they recognized ADHD symptoms in themselves. This may have raised motivation, not only for the adolescent's improvement but also for their own, and may have enhanced the effects of the training for fathers on stress levels, and indirectly on ratings of adolescent's behavior as well, at least partly. The finding that mothers reported no significant improvement may also be the result of the small sample size of our study.

Striking is the finding that fathers reported an increase in parental overreactivity after training, whereas mothers reported the expected reduction. This is in contrast to the findings of Van der Oord et al. (2011), who found a reduction in parental overreactivity. However, their study included mostly mothers (95%), and therefore results were not analyzed for mothers and fathers separately. A possible explanation is that fathers became more aware of their parental overreactivity during the MP training but were not able to change this, whereas mothers were able to. In fact, fathers reported lower parental overreactivity at pretest than mothers, although the difference was not significant.

With regard to the computerized attention measures, the finding that adolescents showed inconsistencies in their improvements on attention, impulsivity and reaction speed measures of the visual and auditory sustained attention tasks, could be explained by the different types of information processing the tasks tap into (Jonkman et al. 1997). We also found inconsistencies between different measurement occasions, with some effects appearing directly after training, and others appearing at follow-up. Little is known about the duration and time of appearance of treatment effects on different symptoms of ADHD, but perhaps results in larger samples will be more stable, and future studies should investigate this in more detail.

The finding that none of the respondents reported improvement in mindful attention and awareness might be explained by the fact that the MAAS was designed to assess one's general tendency to be mindful over time, or what might be referred to as 'trait' mindfulness (an example item is: *"I rush through activities without being really attentive to them"*) (Schmertz et al. 2008). In the adolescent group the focus was more on an applied form, that is, the ability to deploy attention and awareness when needed, and could be referred to as 'state' mindfulness. This also applied to the parent-group, for whom the emphasis of the training was on learning to be more mindful in their parenting practices, specifically. However, these findings were in contrast with other studies in which improvements on the adolescent version of the MAAS were shown after participation in mindfulness training (i.e., Brown et al. 2011).

Another notable finding is that some effects on report-measures became stronger at 8-weeks follow-up, but seemed to wane at 16-week follow-up. Unfortunately, since we do not have follow-up measurement for all informant groups (e.g. tutors were not included after posttest, parents dropped out after 8-week follow-up), we do not know if these findings are confirmed across informant groups. Also, the failure to reach significance at 16-week follow-up is probably the result of our sample size becoming smaller with each measurement, since effect sizes stayed the same or became larger. The results, however, may suggest that more booster sessions are necessary to sustain or enhance treatment effects.

Alongside the strong points of our pilot-study (multiple informants, objective neuropsychological attention measures, two follow-up measurements, and the combination of mindfulness training and MP training for adolescents and parents respectively), our study has several limitations that should be mentioned. First, the sample size was small and therefore generalization of the findings is limited. Studies using larger sample sizes are needed to replicate these findings. Second, this study was based on a quasi-experimental design rather than a randomized controlled clinical trial (RCT). Participants were not assigned randomly to treatment and no-treatment or different treatment groups. In future studies, a RCT should be used to compare mindfulness training and MP to no or different treatment. Of particular interest here would be to make the comparison between the previously mentioned parent management training, medication and MP and/or mindfulness training for the adolescents. Third, the effect of the mindfulness training on attention was only objectively investigated in sustained attention, and as a result we cannot draw conclusions about the effects on other aspects of attention (e.g., focused or divided attention). Fourth, the relative contribution of parent and adolescent training to the improvements reported is unknown due to parallel training, and therefore it is unknown which aspects are (most) effective. Although our clinical judgment is that the effectiveness of the mindfulness training lays in the parallel training for an important part, the comparison of the combination of MP plus mindfulness training for the adolescents, versus MP *or* mindfulness training for the adolescents alone might disentangle these effects.

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