World Journal of Psychiatry

Submit a Manuscript: http://www.wjgnet.com/esps/
Help Desk: http://www.wjgnet.com/esps/helpdesk.aspx
DOI: 10.5498/wjp.v5.i4.397

World J Psychiatr 2015 December 22; 5(4): 397-403
ISSN 2220-3206 (online)
© 2015 Baishideng Publishing Group Inc. All rights reserved.

Does mindfulness meditation improve attention in attention deficit hyperactivity disorder?

Vania Modesto-Lowe, Pantea Farahmand, Margaret Chaplin, Lauren Sarro

Vania Modesto-Lowe, Department of Mental Health and Addiction Services, Connecticut Valley Hospital, Middletown, CT 06457, United States

Vania Modesto-Lowe, Pantea Farahmand, Department of Psychiatry, University of Connecticut School of Medicine, Farmington, CT 06030, United States

Vania Modesto-Lowe, Lauren Sarro, Physician Assistant Program, Quinnipiac University, Hamden, CT 06518, United States

Margaret Chaplin, Adult Outpatient Department, Connecticut Mental Health Center, New Britain, CT 06051, United States

Author contributions: Modesto-Lowe V and Chaplin M wrote the majority of the first draft; Farahmand P wrote the majority of the second draft including an addition on the effects of mindfulness on attention; Sarro L wrote the clinical section, helped rewrite the subsequent drafts and edited each version.

Conflict-of-interest statement: The senior author and coauthors of this paper have no conflicts of interest to disclose.

Open-Access: This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/

Correspondence to: Vania Modesto-Lowe, MD, MPH, Physician, Department of Mental Health and Addiction Services, Connecticut Valley Hospital, PO Box 351, Silver Street, Middletown, CT 06457, United States. vania.modesto-lowe@ct.gov
Telephone: +1-860-2626358
Fax: +1-860-2626121

Received: June 12, 2015
Peer-review started: June 15, 2015
First decision: August 25, 2015
Revised: September 8, 2015
Accepted: October 16, 2015
Article in press: October 19, 2015
Published online: December 22, 2015

Abstract

Attention deficit hyperactivity disorder (ADHD) manifests by high levels of inattention, impulsiveness and hyperactivity. ADHD starts in childhood and results in impairments that continue into adulthood. While hyperactivity declines over time, inattention and executive function difficulties persist, leading to functional deficits. Adolescents and adults with ADHD have pervasive impairment in interpersonal and family relationships. They may develop addiction, delinquent behavior and comorbid psychiatric disorders. Despite advances in diagnosis and treatment, persistent residual symptoms are common, highlighting the need for novel treatment strategies. Mindfulness training, derived from Eastern meditation practices, may improve self-regulation of attention. It may also be a useful strategy to augment standard ADHD treatments and may be used as a potential tool to reduce impairments in patients with residual symptoms of ADHD. Clinically, this would manifest by an increased ability to suppress task-unrelated thoughts and distractions resulting in improved attention, completion of tasks and potential improvement in occupational and social function.

Key words: Attention deficit hyperactivity disorder; Mindfulness; Treatment adjunct; Inattention; Meditation; Attention

© The Author(s) 2015. Published by Baishideng Publishing Group Inc. All rights reserved.

Core tip: Attention deficit hyperactivity disorder (ADHD) is a chronic and potentially handicapping developmental disorder that affects both children and adults. Recent advances in research have led to improved screening,

diagnostic algorithms, pharmacologic and psychosocial treatment for patients with ADHD. However, impairing residual symptoms persist for most affected individuals. This article explores empirical evidence supporting the use of meditation for inattention in ADHD. The results of the study have found evidence for mindfulness training as a potentially effective treatment for residual inattention after pharmacological treatment of ADHD. Adequately powered prospective studies are needed to firmly establish efficacy.

Modesto-Lowe V, Farahmand P, Chaplin M, Sarro L. Does mindfulness meditation improve attention in attention deficit hyperactivity disorder? *World J Psychiatr* 2015; 5(4): 397-403 Available from: URL: http://www.wjgnet.com/2220-3206/full/v5/i4/397.htm DOI: http://dx.doi.org/10.5498/wjp.v5.i4.397

INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) affects 5% of children and 4% of adults. It is characterized by inattention, hyperactivity and impulsivity inconsistent with age. These characteristics result in dysfunctional social, academic and occupational environments[1-3]. Children are at risk for a range of problems including low self-esteem, peer rejection, physical injuries and poor adaptive functioning[2]. Similarly, adolescents with ADHD have significant difficulties with executive function and behavioral inhibition. They tend to make decisions impulsively and are prone to use alcohol, tobacco and other substances in comparison to adolescents without ADHD[4-6]. Furthermore, early onset of sexual activity, accidents, delinquency and reckless driving is heightened in adolescents with ADHD[7]. ADHD symptoms may also cause impairment in adult patients[8]. Similar to younger groups, adults with ADHD experience difficulties in academics, work, interpersonal areas and life skills, such as driving and parenting. They tend to have high rates of substance use, unemployment, divorce, antisocial behaviors and psychiatric comorbidities[9]. Overall, available data suggests that ADHD is a chronic handicapping condition associated with negative outcomes across the life span.

Recent advances in research have led to improved screening, diagnostic algorithms, as well as pharmacologic and psychosocial treatment for patients with ADHD[2,3,10]. In the United States, stimulants remain the first line pharmacotherapy and are associated with a remarkable response rate; however, despite the use of stimulants, impairing residual symptoms persist for most affected individuals[11]. Behavioral training for parents of affected children and cognitive behavioral therapy in older groups to augment the effects of medications has shown some promise[9]. Unfortunately, most studies in this area only evaluate the short-term outcomes of these therapies, and the long-term benefits remain unclear[5,10]. The interest in developing sustainable, non-pharmacological options to augment ADHD treatments has led to interest in mindfulness training (MT). MT is an intervention derived from Buddhist practices that may enhance attention and reduce impulsive responses[12]. The core aspects of mindfulness involve paying attention on purpose in the present moment and with nonjudgmental acceptance. Over the past few years MT has been adapted for use in clinical populations including adolescents and adults who have difficulties regulating their emotions and behaviors[13,14]. This article outlines the clinical presentation and neurobiology of ADHD and explores empirical evidence supporting the use of meditation for inattention in ADHD.

CLINICAL FEATURES OF ADHD

ADHD is a neurodevelopmental disorder that typically presents in childhood and is characterized by troubles with inattention, hyperactivity and/or impulsivity[1,15]. According to the DSM-5, the diagnosis requires at least six symptoms of either inattention or hyperactivity/impulsivity, several of which must be present prior to the onset of adolescence. For individuals over the age of seventeen, only five symptoms are necessary for diagnosis. These symptoms must be present for at least 6 mo, occur in at least two settings, and hinder social, academic and/or occupational functioning[15]. ADHD is often thought of as a disorder of childhood; however, the reality is that it often persists into adolescence and adulthood[16].

The symptom presentation of ADHD differs across the lifespan. As individuals reach adolescence, the hyperactivity tends to abate somewhat while the inattention persists and often becomes more disabling[16,17]. In adolescence, impulsivity often presents as recklessness, unpremeditated actions and impatience. Similarly, the characteristic rambunctiousness of children with ADHD recedes and is replaced by motor restlessness. Adolescents with ADHD report feeling on edge and often choose activities that are physical in nature in order to avoid sedentary tasks. Despite the significant presence of restlessness, a study conducted by Sibley *et al*[16] found the symptoms of inattention to far outweigh those of hyperactivity/impulsivity in adolescence. Inattention is manifested by distractibility, carelessness, forgetfulness and organizational difficulty. Adolescents with ADHD have difficulty focusing during lectures or while reading; they complain of their mind "wandering" and often have difficulty listening, following through on instructions or finishing tasks. They frequently lose or misplace items and characteristically work in cluttered and disorganized environments. Additionally, there is a penchant to procrastinate and avoid activities that require prolonged attention. The difficulty with sustaining attention leads to marked school difficulties. Struggles with studying or paying attention in class can lead to academic decline and failure[18]. Adults often run the risk of unemployment due to ADHD jeopardizing job performance and acceptable attendance records. Socially, relationships

with others are threatened as inattention is seen as laziness, irresponsibility and unwillingness to cooperate[15]. While current pharmacological and behavioral treatments can reduce debilitating symptoms significantly, partial remission is common and residual difficulty with focus, impulse control and emotional regulation cause significant dysfunction for many adolescents and adults with ADHD.

NEUROBIOLOGY OF ADHD

Neurobiological research has tied ADHD symptoms to structural-functional brain abnormalities and delayed development of the neocortex[19]. As children develop, brain maturation progresses in a posteroanterior fashion. Initially, myelination takes place in the visual pathway and then progresses to anterior areas such as the prefrontal cortex (PFC). The brain development that occurs during adolescence primarily involves changes in the frontal and parietal cortices, the sites responsible for executive function. A peak in gray matter volume at puberty is followed by a gradual decline, as the cortex undergoes synaptic pruning in areas that play a role in impulse control, planning and emotion regulation. The evolutional path of the brain in children with ADHD follows a parallel course with controls, but always with significantly smaller gray matter volumes[20]. Traditional magnetic resonance imaging (MRI) studies in children with ADHD have shown reduced volume in the frontal cortex, anterior cingulate cortex (ACC), basal ganglia and cerebellum[21]. Similarly, structural MRI studies in adults with ADHD have found overall reductions in cortical gray matter volume in the ACC, orbitofrontal cortex (OFC), inferior frontal cortex, dorsolateral prefrontal cortex (DLPFC), temporoparietal, cerebellar and occipital regions[22-25]. While volumetric reductions in subcortical areas have also been reported in adults with ADHD, most research focused on the frontal striatum circuit including the ACC, OFC and DLPFC.

Early research implicates dysfunction of the PFC and fronto-striatal circuitry in ADHD, including the OFC, DLPFC and ACC. The ACC modulates the peripheral nervous system (PNS) and the central locus ceruleus (LC), both norepinephrine (NE)-driven systems. For the most part, the ACC is activated by novel or salient stimuli as part of a neural circuit that serves to regulate cognitive and emotional processing. By rapidly modulating the activity levels of both principal NE systems, the ACC is able to adapt the state of the whole organism to optimize attention and support complex behavior. It is also responsible for selective attention and conflict monitoring. Furthermore, the ACC is the primary structure responsible for salience and detection of executive PFC networks. These networks integrate input from the internal and external environments to maximize adaptive processes[26]. The PFC provides top-down (cerebral-to-limbic) regulation of attention and behavioral inhibition through connections with posterior cortical and subcortical structures[27]. The OFC is involved in decision-making and impulsivity. The function of the DLPFC is to sustain attention, problem solve and organize information[28]. It has also been implicated in activating the brain mechanisms necessary for working memory and task completion. Overall, these PFC structures act in concert as well as communicate with subcortical structures (*e.g.*, basal ganglia, cerebellum) to optimize attention and executive function[29]. The catecholamine neurotransmitters, dopamine and NE, are critical for communication between the PFC and other brain structures[27]. Concentrations of these neurotransmitters in the PFC follow a bimodal curve: too much or too little disrupts its functioning. In persons afflicted with ADHD, poor connectivity among these brain areas may underlie the pathology associated with impaired goal setting, organization and planning.

Functional MRI (fMRI) technology has been used to map out brain-symptom correlations in ADHD. It assesses brain activity by measuring hemodynamic response in different regions of the brain under various cognitive tasks. In ADHD studies, fMRI findings have suggested that individuals with ADHD have hypoactivity in the PFC areas, superior parietal areas, caudate nucleus and thalamus[30]. These changes that result in impairment with tasks requiring attention and response inhibition have been show to normalize with appropriate treatment.

Overall efforts to delineate the neural systems underlying attention control in individuals with ADHD do not suggest a simple locus of neural dysfunction, but rather a deficit in integration of information across numerous brain areas[31]. Generally, the literature indicates that ADHD is characterized by multiple functional and structural neural network abnormalities beyond the classical fronto-striatal model, including fronto-parietal-temporal, fronto-cerebellar and even fronto-limbic networks.

MINDFULNESS MEDITATION

Mindfulness is a technique of focusing attention that is derived from Eastern meditation practices. It has been defined as "bringing one's complete attention to experience the present moment"[32]. The basic elements of MT are intention, attitude and attention. The ability to direct one's attention can be developed through the practice of intentional self-regulation of attention from moment to moment[13]. Mindfulness has been conceptualized as a fundamental way of being, and is a learned skill involving non-judgmental observation of thoughts, emotions and somatic sensations that arise in one's awareness[33]. Over the past several years, researchers have been exploring the therapeutic potential of MT[34]. These efforts have included development of manuals that apply MT principles to Western psychotherapy. In the United States, the most frequently cited method of MT is mindfulness-based stress reduction, which was first used for the treatment of chronic pain[35]. The use of MT has since been extended to other clinical populations, and

has garnered acceptance as a legitimate psychotherapy modality[36]. Although research in ADHD is limited, some studies have documented improvements in attention skills in adolescents, as well as adults with ADHD[13,37].

When considering the various types of practices, two types of meditation are broadly recognized: focused and receptive attention. As the name implies, focused or concentrative meditation entails focusing on a specific thought, such as an image or body sensation, while distracting events are disregarded[26]. This allows the meditator to concentrate on one thing at a time rather than allowing attention to split among tasks. One example is the mindfulness of breathing, where a participant is trained to focus on his/her breathing and sustain attention on this sensation for the practice duration. The training includes explicit instructions to notice mind wandering and respond by redirecting attention. If the participant notices his/her attention wander away from the breath, he or she must notice the drift in attention and return to the breath. This practice leads to less distractibility and better ability to stay on task.

Another type of meditation, called open monitoring or receptive attention, includes observing the content of one's experience (*e.g*., sensations, thoughts and emotions) from moment to moment without reacting. In the open monitoring meditation, attention is extended to the whole field of awareness. It involves being alert to any stimuli that arise in the moment rather than a steady focus on one specific object. This type of meditation enhances attention switching, the ability to purposefully shift the attention focus between stimuli[38]. By directing attention to the experience of the moment, subjects learn to identify and dismiss unhelpful automatic reactions. This improvement in receptive attention can improve self-regulation and impulse control.

MT AND ATTENTION

By enhancing attention, MT can potentially improve several core symptoms of ADHD, namely task completion, self-regulation and impulse control. Given its low cost and sustainability, it is of interest to clinicians to empirically validate the positive effect of MT on attention. Early research has studied the benefits of concentrative meditation using the Posner model of attention. According to Posner[39], the attention system is supported by three components: alerting, orienting and conflict monitoring. The alerting network attains and sustains a state of vigilance and is subserved by the reticular activating system. The orienting subsystem involves the parietal lobe. Its function is to select relevant environmental information and enable one to react quickly to a situation. The conflict monitoring subsystem prioritizes competing stimuli to regulate thoughts, emotions and actions. The ACC plays an important role in conflict monitoring by anticipating what to do next in situations. It has been proposed that MT's capacity to influence attention relates to its ability to act on these three attention processes[40].

In a study by Jha *et al*[41], the effects of focused MT on the elements of attention, including alerting, orienting, and conflict monitoring, were examined. Participants were divided into three groups - a novice group, who received 8 wk of training in MT, an experienced MT group and a meditation naïve control group. The novice participants were taught to focus attention, detect distraction, then disengage their attention from the source of distraction, and flexibly redirect and engage attention to an intended object. The experienced MT group participated in a 4-wk meditation retreat. On the first evaluation, the participants in the retreat group demonstrated improved conflict monitoring performance relative to those in the novice MT groups and controls. At follow up, those in the novice MT groups demonstrated significantly improved orienting in comparison with the other groups. These results suggest that MT may improve certain aspects of attention[41]. Another study by Tang *et al*[42], focused on the effects of short-term meditation on attention. Participants included forty Chinese college students randomly assigned to 5 d of either MT or relaxation. Results showed that there was an advantage of MT in conflict monitoring relative to the group that received relaxation. Apart from these studies, additional data supports that focused MT practice improves conflict monitoring and orienting[43,44].

A study by Chiesa *et al*[36] reviewed research evaluating the effects of MT on measures of cognitive function. This review supports the notion that focused MT may be associated with significant improvements in conflict monitoring. One proposed theory suggests that the mechanism underlying the effect of MT on conflict monitoring functions *via* activation of the attention-related cortices such as the PFC and ACC[36,45]. Efforts to elucidate the meditation-attention link have measured brain activation before and after variable periods of MT using fMRI[36]. One of the most frequently observed changes in response to meditation is the activation of the PFC and the ACC[26]. Activation of the ACC is typically accompanied by a widespread activation of other brain areas such as the LC and the autonomic nervous system. The LC is thought to optimize behavioral performance by modulating arousal and adaptively responding to environmental demands[46]. There is an inverse relationship between cortical arousal and peripheral sympathetic nervous system (SNS) arousal. It is believed that meditation acutely activates the ACC, which in turn inhibits the SNS, and decreases peripheral NE drives. The result is parasympathetic activation and relaxation promotion. At the same time, the ACC signals LC activation and an increase in cortical NE release, which results in enhanced attention processes.

Additional research has explored the effects of cognitive behavioral therapy and MT (CBT/MT) on attention in incarcerated adolescents. In this study, by Leonard *et al*[47], the investigators randomly assigned dormitories of incarcerated youth, ages 16-18, to a CBT/

MT intervention (n = 147) or a control intervention (n = 117). Both arms received about 750 min of training in small groups over a 3-5 wk period. Youth in the CBT/MT arm also reported on the amount of homework practicing MT exercises. The Attention Network Test was employed to measure attention performance at baseline and at 4-mo follow-up. The results of the study found that multi-session CBT/MT interventions had a protective effect on the incarcerated youths' attention capabilities[47]. Overall, there is emerging evidence that MT has an impact on attention capacity, which encourages its adaptation and application to patients with ADHD.

MT IN ADHD PATIENTS

The use of meditation with ADHD populations is in its nascence[48]. In 2008, Zylowska *et al*[32] conducted a feasibility study, which adapted MT for adolescents and adults with ADHD. Subjects consisted of 24 adults and eight adolescents with ADHD who were treated with 8 wk of MT along with homework assignments. The curriculum, called Mindful Awareness Program, adapted to the specific requirements of persons with ADHD and included education in practices that ameliorate self-regulation and MT exercises. Participants began by meditating for 5 min at a time and gradually increased to 20 min. Each session lasted 2.5 h and was supplemented with daily at-home practice (CD's with guided meditations). The results were promising with 78% completing the study and 30% reporting a greater than 30% reduction in symptoms of ADHD (*i.e.*, set shifting and conflict attention)[13]. The authors concluded that an 8-wk MT adapted for adolescents and adults with ADHD was feasible; however, without a control group it is not clear whether the improvement in attention was due to the MT or non-specific factors.

Mitchell *et al*[49] also completed a study of the feasibility and acceptability of mindfulness meditation for adults with ADHD[49]. They compared a sample of 11 adults against a control group of 11, and found MT without additional ADHD treatment modalities was both feasible and acceptable to the participants. Sixty-three point six percent in the treatment group also rated a $\geqslant$ 30% reduction in inattention and hyperactivity symptoms compared to 0% reduction in the control group in self-rating scales. These results paralleled the in the clinician rating assessments (inattention and hyperactivity reductions of 81.8% and 72.7% in the treatment group *vs* 0% and 11% reductions respectively in the control group). Overall, these studies show evidence of acceptability and feasibility in MT[50]. However, controlled trials exploring MT as an attention enhancing strategy in the treatment of adult ADHD are needed to strengthen the evidence for MT's usefulness.

CONCLUSION

ADHD is characterized by inattention, hyperactivity and impulsivity. It is a common developmental disorder that can persist throughout life and cause significant impairment in social, academic and occupational functioning. Although various treatment approaches exist, including pharmacologic and psychosocial treatments, residual symptoms persist for most affected individuals. In recent years, MT has been explored in ADHD populations to address ongoing distractibility, emotional dysregulation and impulsivity. Evidence suggests that certain meditative practices improve attention and may ameliorate the symptoms of ADHD by activating brain regions implicated in both sustaining and directing attention. There is much to gain from an improved understanding of the possible role of MT in enhancing attention. Overall, these findings support the idea that deliberate cultivation of attention using MT may prove to be a useful strategy to ameliorate residual inattention after pharmacological treatment of ADHD. However, adequately powered prospective studies of the relationship between meditation and inattention in ADHD populations are needed to firmly establish efficacy.

REFERENCES

1 **King JA**, Barkley RA, Barrett S. Attention-deficit hyperactivity disorder and the stress response. *Biol Psychiatry* 1998; **44**: 72-74 [PMID: 9646887 DOI: 10.1016/S0006-3223(97)00507-6]

2 **Asherson P**, Akehurst R, Kooij JJ, Huss M, Beusterien K, Sasané R, Gholizadeh S, Hodgkins P. Under diagnosis of adult ADHD: cultural influences and societal burden. *J Atten Disord* 2012; **16**: 20S-38S [PMID: 22377849 DOI: 10.1177/1087054711435360]

3 **Primich C**, Iennaco J. Diagnosing adult attention-deficit hyperactivity disorder: the importance of establishing daily life contexts for symptoms and impairments. *J Psychiatr Ment Health Nurs* 2012; **19**: 362-373 [PMID: 22146075 DOI: 10.1111/j.1365-2850.2011.01845.x]

4 **Kessler RC**, Adler L, Barkley R, Biederman J, Conners CK, Demler O, Faraone SV, Greenhill LL, Howes MJ, Secnik K, Spencer T, Ustun TB, Walters EE, Zaslavsky AM. The prevalence and correlates of adult ADHD in the United States: results from the National Comorbidity Survey Replication. *Am J Psychiatry* 2006; **163**: 716-723 [PMID: 16585449 DOI: 10.1176/ajp.2006.163.4.716]

5 **Kooij SJ**, Bejerot S, Blackwell A, Caci H, Casas-Brugué M, Carpentier PJ, Edvinsson D, Fayyad J, Foeken K, Fitzgerald M, Gaillac V, Ginsberg Y, Henry C, Krause J, Lensing MB, Manor I, Niederhofer H, Nunes-Filipe C, Ohlmeier MD, Oswald P, Pallanti S, Pehlivanidis A, Ramos-Quiroga JA, Rastam M, Ryffel-Rawak D, Stes S, Asherson P. European consensus statement on diagnosis and treatment of adult ADHD: The European Network Adult ADHD. *BMC Psychiatry* 2010; **10**: 67 [PMID: 20815868 DOI: 10.1186/1471-244X-10-67]

6 **Skirrow C**, Hosang GM, Farmer AE, Asherson P. An update on the debated association between ADHD and bipolar disorder across the lifespan. *J Affect Disord* 2012; **141**: 143-159 [PMID: 22633181 DOI: 10.1016/j.jad.2012.04.003]

7 **Harstad EB**, Weaver AL, Katusic SK, Colligan RC, Kumar S, Chan E, Voigt RG, Barbaresi WJ. ADHD, stimulant treatment, and growth: a longitudinal study. *Pediatrics* 2014; **134**: e935-e944 [PMID: 25180281 DOI: 10.1542/peds.2014-0428]

8 **Faraone SV**, Biederman J, Spencer T, Mick E, Murray K, Petty C, Adamson JJ, Monuteaux MC. Diagnosing adult attention deficit hyperactivity disorder: are late onset and subthreshold diagnoses valid? *Am J Psychiatry* 2006; **163**: 1720-1729; quiz 1859 [PMID: 17012682 DOI: 10.1176/appi.ajp.163.10.1720]

9 **Manos MJ**. Psychosocial therapy in the treatment of adults with attention-deficit/hyperactivity disorder. *Postgrad Med* 2013; **125**:

51-64 [PMID: 23816771 DOI: 10.3810/pgm.2013.03.2641]
10 **Nutt DJ**, Fone K, Asherson P, Bramble D, Hill P, Matthews K, Morris KA, Santosh P, Sonuga-Barke E, Taylor E, Weiss M, Young S. Evidence-based guidelines for management of attention-deficit/hyperactivity disorder in adolescents in transition to adult services and in adults: recommendations from the British Association for Psychopharmacology. *J Psychopharmacol* 2007; **21**: 10-41 [PMID: 17092962 DOI: 10.1177/0269881106073219]
11 **van de Weijer-Bergsma E**, Formsma AR, de Bruin EI, Bögels SM. The Effectiveness of Mindfulness Training on Behavioral Problems and Attentional Functioning in Adolescents with ADHD. *J Child Fam Stud* 2012; **21**: 775-787 [PMID: 22993482 DOI: 10.1007/s10826-011-9531-7]
12 **Kabat-Zinn J**. Mindfulness-Based interventions in context: past, present and future. Clinical Psychology: Science and Practice, 2003; **10**: 144-156 [DOI: 10.1093/clipsy.bpg016]
13 **Zylowska L**, Ackerman DL, Yang MH, Futrell JL, Horton NL, Hale TS, Pataki C, Smalley SL. Mindfulness meditation training in adults and adolescents with ADHD: a feasibility study. *J Atten Disord* 2008; **11**: 737-746 [PMID: 18025249 DOI: 10.1177/1087054707308502]
14 **Grosswald SJ**, Stixrud AWR, Travis F, Bateh MA. Use of the transcendental meditation technique to reduce symptoms of attention deficit hyperactivity disorder (ADHD) by reducing stress and anxiety: an exploratory study. *Curr Issues Educ* 2008; **10**: 1-16
15 **American Psychiatric Association**. Attention-deficit/hyperactivity disorder. In: Swedo SE, ed. Diagnostic and Statistical Manual of Mental Disorders, 5th ed. Arlington, Virginia: American Psychiatric Association, 2013: 59-66
16 **Sibley MH**, Pelham WE, Molina BS, Gnagy EM, Waschbusch DA, Garefino AC, Kuriyan AB, Babinski DE, Karch KM. Diagnosing ADHD in adolescence. *J Consult Clin Psychol* 2012; **80**: 139-150 [PMID: 22148878 DOI: 10.1037/a0026577]
17 **Harrison JR**, Vannest KJ, Reynolds CR. Behaviors that discriminate ADHD in children and adolescents: primary symptoms, symptoms of comorbid conditions, or indicators of functional impairment? *J Atten Disord* 2006; **163**: 1720-1729 [DOI: 10.1177/1087054709356170]
18 **Costa Dde S**, Paula JJ, Alvim-Soares Júnior AM, Diniz BS, Romano-Silva MA, Malloy-Diniz LF, Miranda DM. ADHD inattentive symptoms mediate the relationship between intelligence and academic performance in children aged 6-14. *Rev Bras Psiquiatr* 2014; **36**: 313-321 [PMID: 25028778 DOI: 10.1590/1516-4446-2013-1201]
19 **Shaw P**, Eckstrand K, Sharp W, Blumenthal J, Lerch JP, Greenstein D, Clasen L, Evans A, Giedd J, Rapoport JL. Attention-deficit/hyperactivity disorder is characterized by a delay in cortical maturation. *Proc Natl Acad Sci USA* 2007; **104**: 19649-19654 [PMID: 18024590 DOI: 10.1073/pnas.0707741104]
20 **Rohde LA**, Halpern R. [Recent advances on attention deficit/hyperactivity disorder]. *J Pediatr* (Rio J) 2004; **80**: S61-S70 [PMID: 15154074 DOI: 10.2223/1170]
21 **Krain AL**, Castellanos FX. Brain development and ADHD. *Clin Psychol Rev* 2006; **26**: 433-444 [PMID: 16480802 DOI: 10.1016/j.cpr.2006.01.005]
22 **Corbetta M**, Shulman GL. Control of goal-directed and stimulus-driven attention in the brain. *Nat Rev Neurosci* 2002; **3**: 201-215 [PMID: 11994752 DOI: 10.1038/nrn755]
23 **Fan J**, McCandliss BD, Fossella J, Flombaum JI, Posner MI. The activation of attentional networks. *Neuroimage* 2005; **26**: 471-479 [PMID: 15907304 DOI: 10.1016/j.neuroimage.2005.02.004]
24 **Raz A**, Buhle J. Typologies of attentional networks. *Nat Rev Neurosci* 2006; **7**: 367-379 [PMID: 16760917 DOI: 10.10138/nrn1903]
25 **Posner MI**, Rothbart MK. Research on attention networks as a model for the integration of psychological science. *Annu Rev Psychol* 2007; **58**: 1-23 [PMID: 17029565 DOI: 10.1146/annurev.psych.58.110405.085516]
26 **Hölzel BK**, Ott U, Hempel H, Hackl A, Wolf K, Stark R, Vaitl D. Differential engagement of anterior cingulate and adjacent medial frontal cortex in adept meditators and non-meditators. *Neurosci Lett* 2007; **421**: 16-21 [PMID: 17548160 DOI: 10.1016/j.neulet.2007.04.074]
27 **Arnsten AF**, Rubia K. Neurobiological circuits regulating attention, cognitive control, motivation, and emotion: disruptions in neurodevelopmental psychiatric disorders. *J Am Acad Child Adolesc Psychiatry* 2012; **51**: 356-367 [PMID: 22449642 DOI: 10.1016/j.jaac.2012.01.008]
28 **Shulman GL**, Pope DL, Astafiev SV, McAvoy MP, Snyder AZ, Corbetta M. Right hemisphere dominance during spatial selective attention and target detection occurs outside the dorsal frontoparietal network. *J Neurosci* 2010; **30**: 3640-3651 [PMID: 20219998 DOI: 10.1523/JNEUROSCI.4085-09.2010]
29 **Rueda MR**, Checa P, Cómbita LM. Enhanced efficiency of the executive attention network after training in preschool children: immediate changes and effects after two months. *Dev Cogn Neurosci* 2012; **2** Suppl 1: S192-S204 [PMID: 22682908 DOI: 10.1016/j.dcn.2011.09.004]
30 **Dickstein DL**, Kabaso D, Rocher AB, Luebke JI, Wearne SL, Hof PR. Changes in the structural complexity of the aged brain. *Aging Cell* 2007; **6**: 275-284 [PMID: 17465981 DOI: 10.1111/j.1474-9726.2007.00289.x]
31 **Baruch DE**, Kanter JW, Busche AM, Juskiewicz KL. Enhancing the therapy relationship in acceptance and commitment therapy for psychotic symptoms. *Clinical Case Studies* 2009; **8**: 241-57 [DOI: 10.1177/1534650109334818]
32 **Zylowska L**, Smalley SL, Schwartz JM. Mindful awareness and ADHD. In Didonna F, ed. Clinical handbook of mindfulness. New York, NY: Springer, 2009: 319-338 [DOI: 10.1007/978-0-387-09593-6]
33 **Shapiro SL**, Carlson LE. The art and science of mindfulness: Integrating mindfulness into psychology and the helping professions Washington, DC: American Psychological Association, 2009
34 **Hofmann SG**, Sawyer AT, Witt AA, Oh D. The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review. *J Consult Clin Psychol* 2010; **78**: 169-183 [PMID: 20350028 DOI: 10.1037/a0018555]
35 **Kabat-Zinn J**. Full catastrophe living: Using the wisdom of your body and mind to face stress, pain, and illness. New York, NY: Dell, 1990
36 **Chiesa A**, Serretti A. Mindfulness based cognitive therapy for psychiatric disorders: a systematic review and meta-analysis. *Psychiatry Res* 2011; **187**: 441-453 [PMID: 20846726 DOI: 10.1016/j.psychres.2010.08.011]
37 **Broderick PC**, Jennings PA. Mindfulness for adolescents: a promising approach to supporting emotion regulation and preventing risky behavior. *New Dir Youth Dev* 2012; **2012**: 111-126, 111 [PMID: 23359447 DOI: 10.1002/yd.20042]
38 **Chambers R**, Lo BCY, Allen NB. The impact of intensive mindfulness training on attentional control, cognitive style, and affect. *Cognit Ther Res* 2008; **32**: 303-22 [DOI: 10.1007/s10608-007-9119-0]
39 **Posner MI**, Petersen SE. The attention system of the human brain. *Annu Rev Neurosci* 1990; **13**: 25-42 [PMID: 2183676]
40 **Cassone AR**. Mindfulness training as an adjunct to evidence-based treatment for ADHD within families. *J Atten Disord* 2015; **19**: 147-157 [PMID: 23704114 DOI: 10.1177/1087054713488438]
41 **Jha AP**, Krompinger J, Baime MJ. Mindfulness training modifies subsystems of attention. *Cogn Affect Behav Neurosci* 2007; **7**: 109-119 [PMID: 17672382 DOI: 10.3758/cabn.7.2.109]
42 **Tang YY**, Ma Y, Wang J, Fan Y, Feng S, Lu Q, Yu Q, Sui D, Rothbart MK, Fan M, Posner MI. Short-term meditation training improves attention and self-regulation. *Proc Natl Acad Sci USA* 2007; **104**: 17152-17156 [PMID: 17940025 DOI: 10.1073/pnas.0707678104]
43 **van den Hurk PA**, Giommi F, Gielen SC, Speckens AE, Barendregt HP. Greater efficiency in attentional processing related to mindfulness meditation. *Q J Exp Psychol* (Hove) 2010; **63**: 1168-1180 [PMID: 20509209 DOI: 10.1080/17470210903249365]
44 **Chan D**, Woollacott M. Effects of level of meditation experience

on attentional focus: is the efficiency of executive or orientation networks improved? *J Altern Complement Med* 2007; **13**: 651-657 [PMID: 17718648 DOI: 10.1089/acm.2007.7022]

45 **Grant JA**, Courtemanche J, Duerden EG, Duncan GH, Rainville P. Cortical thickness and pain sensitivity in zen meditators. *Emotion* 2010; **10**: 43-53 [PMID: 20141301 DOI: 10.1037/a0018334]

46 **Aston-Jones G**, Cohen JD. An integrative theory of locus coeruleus-norepinephrine function: adaptive gain and optimal performance. *Annu Rev Neurosci* 2005; **28**: 403-450 [PMID: 16022602 DOI: 10.1146/annurev.neuro.28.061604.135709]

47 **Leonard NR**, Jha AP, Casarjian B, Goolsarran M, Garcia C, Cleland CM, Gwadz MV, Massey Z. Mindfulness training improves attentional task performance in incarcerated youth: a group randomized controlled intervention trial. *Front Psychol* 2013; **4**: 792 [PMID: 24265621 DOI: 10.3389/fpsyg.2013.00792]

48 **Craigmyle NA**. The beneficial effects of meditation: contribution of the anterior cingulate and locus coeruleus. *Front Psychol* 2013; **4**: 731 [PMID: 24137145 DOI: 10.3389/fpsyg.2013.00731]

49 **Mitchell JT**, McIntyre EM, English JS, Dennis MF, Beckham JC, Kollins SH. A Comparison of Mindfulness-Based Group Training and Skills Group Training in Adults With ADHD: An Open Study. *J Atten Disord* 2014 [PMID: 25300813 DOI: 10.1177/1087054714551635]

50 **Mitchell JT**, Zylowska L, Kollins SH. Mindfulness Meditation Training for Attention-Deficit/Hyperactivity Disorder in Adulthood: Current Empirical Support, Treatment Overview, and Future Directions. *Cogn Behav Pract* 2015; **22**: 172-191 [PMID: 25908900 DOI: 10.1016/j.cbpra.2014.10.002]

P- Reviewer: Yew DT
S- Editor: Ji FF **L- Editor**: A **E- Editor**: Jiao XK

Published by **Baishideng Publishing Group Inc**
8226 Regency Drive, Pleasanton, CA 94588, USA
Telephone: +1-925-223-8242
Fax: +1-925-223-8243
E-mail: bpgoffice@wjgnet.com
Help Desk: http://www.wjgnet.com/esps/helpdesk.aspx
http://www.wjgnet.com

© 2015 Baishideng Publishing Group Inc. All rights reserved.