

Complementary and Alternative Medicine as a Treatment Option for Children with Attention
Deficit Hyperactivity Disorder

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INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) is the most common neurodevelopmental disorder, in which approximately 5-10% of children are diagnosed with ADHD.⁶⁵ ADHD is characterized by symptoms of inattention and/or impulsivity-hyperactivity. The most common method for treating this disorder is through prescription drugs such as Adderall and Ritalin or Methylphenidate. The side effects of these drugs can negatively impact a child's quality of life. These drugs have many known side effects, including sleep problems (insomnia), nervousness, restlessness, weight loss, vomiting, loss of appetite, blurred vision and dizziness.⁶⁵ The following overview focuses on alternative methods for treating ADHD, such as herbal or natural medicine as well as comparing the side effects of the alternative methods to the side effects of prescription drugs. The main outcome of this thesis is to acquire a better understanding of alternate ways to treat children with ADHD. This information will provide parents, children, and physicians with natural ways of treating ADHD such as herbs, exercise, or other activities. Children who suffer from ADHD will benefit from these alternative treatment options as they lower the severity of their symptoms without adding additional symptoms or side effects.

In the specific case of ADHD, it is very common for a physician to prescribe a drug such as Adderall or Ritalin without much concern for possible side effects. Unfortunately, many children suffer from the side effects of these drugs. These children have sleeping problems where they are constantly tired or always feeling sick. This not only affects their physical health but also their mental health and social skills. By always feeling tired and sick this may hinder them from participating in activities or interacting with other children. This can result in a poor quality of life for the child. Therefore, complementary and alternative methods (CAM) should be

considered as part of a child's treatment plan, as these methods can be crucial in providing the best outcome for these patients. Through these alternative methods research suggests that these children will have a better quality of life.

To fully understand and analyze the variety of treatment options for children with ADHD and to establish the optimum or ideal treatment option, a literature search and analytical review were conducted of current research and existing sources. To be considered in this study, articles had to be scholarly and peer reviewed, full-length written reports regarding methods to treat children with ADHD. Only articles published in the English language were included. Included in this study were both literature reviews and experimental studies.

Experimental studies included children and adolescents as participants, between the ages of 2-18 years. Any studies including participants with comorbidities were excluded from this research to control any misidentified factors. During the selection process, abstracts and search results were read to determine the practicality and relevance of the studies. Comparative and non-comparative research were both part of this study. The comparative research had to include a healthy control group as well as a group of children with ADHD. Non-comparative research of methods that helped with treating specific symptoms of ADHD were also included in this study. All the research was gathered and evaluated in order to rationalize the results.

BACKGROUND

The Kynurenine Pathway

The neurobiology of the kynurenine pathway in the brain has been closely researched for many years due to its involvement in physiology in major brain diseases and neurodegenerative disorders. Interest in this pathway is escalating rapidly, with increased recognition that

kynurenine and its metabolites are able to indirectly or directly impact a variety of classic neurotransmitter systems.⁶⁰ Research has supported the involvement of the kynurenine pathway in the pathophysiology of ADHD.²¹

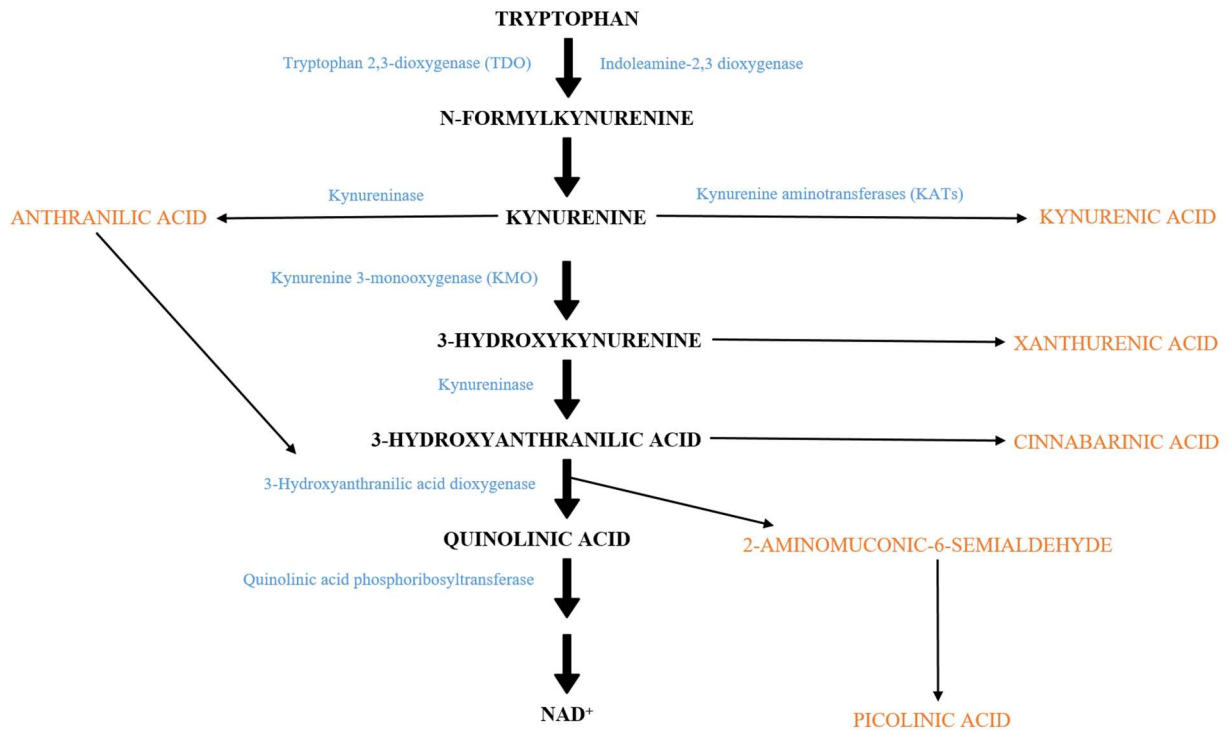


Figure 1. The kynurenine pathway of tryptophan degradation.⁶⁰

The Kynurenine pathway is initiated by the oxidative metabolism of tryptophan. It was originally viewed as the synthetic route to nicotinamide and therefore nicotinamide adenine dinucleotide (NAD⁺). NAD⁺ is considered a vital co-factor for a variety of enzymes throughout the body.⁶⁰ It is also noted that a majority of the enzymes in the cascade are vitamin B6 dependent.⁸ This relationship makes sense as vitamin B6 is involved in forming neurotransmitters, which is needed for normal brain development and function. It helps the body make hormones such as melatonin, which helps regulate the body's circadian rhythm, and serotonin and norepinephrine, which helps regulate mood. The coenzyme form of vitamin B6 or

pyridoxal 5'-phosphate (PLP) is important for the metabolism of neurotransmitters such as serotonin, dopamine, glutamate, glycine, and γ -aminobutyric acid (GABA). Tryptophan catabolism in the kynurenine pathway involves several PLP-dependent reactions.⁷⁰

A study measured serum levels of tryptophan and other metabolites of the kynurenine pathway in 62 healthy children (control) and in 102 children with ADHD by liquid chromatography-tandem mass spectrometry.²¹ Children with ADHD compared to healthy controls showed increased levels of tryptophan and kynurenine, but decreased levels of anthranilic acid, kynurenic acid, and xanthurenic acid, as shown in Figure 2. In this study the presence of ADHD could be predicted by high levels of tryptophan and low levels of anthranilic acid.²¹ This suggests that tryptophan and anthranilic acid should be further investigated as possible biomarkers for ADHD. The significant decrease of anthranilic acid was correlated with a two-fold increase in kynurenine levels. This information strongly indicates that “the activity of kynureninase—the enzyme that converts kynurenine into anthranilic acid—is defective in children with ADHD”.²¹

Tryptophan	Increased	+11.0%
Kynurenine	Increased	+48.6%
Anthranilic Acid	Decreased	-60.0%
Kynurenic Acid	Decreased	-11.2%
Xanthurenic Acid	Decreased	-12.5%
Quinolinic Acid	Unchanged	_____

Figure 2. Serum levels of children with ADHD compared to healthy controls.²¹

The Role of Neuroimaging

To understand the neurobiological perspective of ADHD researches have explored brain imaging using magnetic resonance imaging (MRI). Using the MRI, researches have consistently reported specific regional differences in the frontal cortex, corpus callosum, temporal and parietal cortices, and striatum/basal ganglia.^{10, 11, 12, 13, 24, 29, 40, 48, 63} Researchers have also found an overall volume reduction in total cerebrum.^{10, 13, 45, 49, 61} These types of studies and imaging allows for scientists and medical professionals to understand the brain as a “network” or connectivity system. Most research examining brain connectivity in ADHD uses resting state fMRI to focus on functional connectivity.¹⁰ These studies indicate that children with ADHD present with a disruption within the white matter networks. Another study examining the adult outcome of childhood ADHD found that “the ‘plasticity’ underpinning remission from ADHD lies in inferior prefrontal/cerebellar rather than striatal regions”.⁶⁷

Another neuroimaging study established ADHD-predominately inattentive (ADHD-PI) and ADHD-combined type (ADHD-C) to be two distinct disorders by identifying differences in white matter microstructure. Cortical morphology has also been examined to better understand the role symptoms play on executive functioning in children with ADHD. Executive functioning (EF) is a set of mental skills controlled by the frontal lobe that involve mental control and self-regulation. This includes daily skills such as managing time and paying attention. In a population-based pediatric neuroimaging study it was found that symptoms of ADHD were specifically associated with functioning in the realm of attention and executive functioning rather than cognitive functioning in general.⁵⁰ The results of the study indicated that ADHD symptoms were associated with a thinner cortex in all four lobes of the brain and that there seemed to be less gyrification throughout many parts of the brain. Finally, children who had performed poorly

on neuropsychological tasks checking executive function and attention, presented with identical local clusters of less gyrification.⁵⁰

CURRENT RESEARCH

Behavioral Therapy

Cognitive-behavioral therapy is one of the most common ways to treat children with ADHD and other related impairments. Behavior management is focused on targeting functional impairments rather than ADHD symptoms.⁵³ Although medications have been considered an effective treatment for children with ADHD, psychopharmacotherapy is an inadequate treatment when used exclusively.⁶⁴ In a study conducted by Wilens et al⁷³, for instance, 220 adolescents between the ages of 13 and 18, it stated that 52% of the participants who received methylphenidate for the treatment of adolescent ADHD said that they were either “much improved” or “very much improved”. Although this seems like a very hopeful outcome, this also means that 48% of participants were worse, the same, or only minimally improved.⁶⁴ It was also reported in the study that the treatment group (including those who were “much improved” and “very much improved”) still suffered from lingering symptoms post treatment.⁶⁴

In a study of 31 adult patients who continued to have ADHD symptoms despite stable medication treatment, a comparison was conducted between cognitive-behavioral therapy and pharmacotherapy.⁶⁴ The outcome showed that those who were chosen for cognitive-behavioral therapy had a lower independent assessor rated ADHD symptoms.⁶⁴ Another study was conducted with 68 adolescents with ADHD assessing the effects of cognitive-behavioral therapy.^{4, 64} It was found that after core modules such as organization/planning, cognitive restructuring, and improving communication skills, a number of variables were improved

including inattentive symptoms rated by parents and teachers as well as self-reported self-esteem.

Pfiffner's review focuses on behavioral parent training interventions for children at home that can be generalized across different settings.⁵³ Common problems targeted in behavioral therapy include: lack of independence in completing daily tasks, homework problems, and behaviors such as aggression and defiance towards family members. It has been noted that parents of children with ADHD express more negative or ineffective parenting skills, because of this and other factors such as placement in special education classrooms, school failure, and early drop-out, these children are at a higher risk for interpersonal and educational obstacles.^{9, 25, 28, 42,}
⁵³ Fortunately, there are a number of behavioral treatment plans which target these risk factors for ADHD across different settings.

According to Pffifner et al⁵³, the first step in creating a behavioral management interventions is conducting a functional behavioral analysis. This includes identifying target behaviors that need to increase or decrease and identifying environmental influences. These behaviors are defined as objective and measurable. Behavioral therapy is also meant to help overcome negative parent-child interaction patterns. When a parent responds negatively to a child's behavior and then gives in, they are reinforcing the child's negative behavior. Therefore, these behavioral programs start with teaching parents positive parenting skills such as praise, activity rewards, and token economies/point systems which encourage appropriate child behavior and promote a positive parent-child relationship.⁵³

Teachers can also be involved in these behavioral plans. For example, a target behavior could be turning in schoolwork, following directions, or even getting along with peers.⁵³ The teacher will provide a rating for these target behaviors and this daily report card will be sent

home daily. Based on the ratings at school the child will be rewarded at home. Peer involvement could also be part of the behavioral plan. These treatments would include improving social interactions and/or study/organizational skills. Behavioral Parent Training has been confirmed as a long-standing treatment based on strict Evidence Based Treatment (EBT) assessment criteria in three distinct reviews since 1998.^{22, 52, 53, 54} Current research has proposed that behavioral therapy is a successful treatment option that can be used as both an alternative method as well as a complementary method.

Art Therapy

Art Therapy is a unique method of treatment for children with ADHD. A study conducted by Henley (1998)³⁵ explained, “Aggressive or impulsive behaviors related to the hyperactivity or social anxiety can be channelized into socially productive forms of self-regulation through facilitated creativity”. This suggests that activities that allow for creativity help with self-control which improves behaviors of inattention and hyperactivity. In a study of 14 children with ADHD, the effect of an art therapy program to improve symptoms of impulsivity was analyzed.³² According to the author, “impulsivity refers to hurried actions that happen in the moment without foresight and that have high probability of harm”. The study was started in February 2011 and included two sessions per week for each child in both the control and treatment group.³² Each session lasted forty-five minutes. Overall, twenty-five sessions with each child was conducted. It was found that art therapy is an effective mode of treatment in reducing ADHD symptoms for children.

In the studies conducted by Safran and Habib, they explain the benefits of art therapy as “a child-appropriate activity, that uses visual learning skills, lends structure to therapy, and gives

children a way to express themselves".^{32, 58} According to the Association of Natural Psychology, art therapy may be one of the most single effective therapies to help children and adults to focus, slow down and stabilize.⁷ Art therapy is able to engage the minds of these children as well as calm their emotions. The art making process allows therapists to identify inappropriate behaviors and to understand each child's unique insight on their symptoms and the environment around them.³²

Physical Exercise

Many studies have shown that physical exercise can improve symptoms of ADHD in children such as inattention, restlessness and impulsivity; therefore, resulting in better school performance. In a study measuring the effect of physical exercise on the concentration of children with ADHD, fifty-six volunteers ages 10-16 years old participated.⁶² These volunteers were split up into two groups of 28 participants: the control group and the group with ADHD. The group with ADHD was then further split up into two subgroups: ADHD participants who performed physical activity and ADHD participants that did not participate in physical activity. Each participant was tested on their performance in a computer game.⁶²

It was observed that the group with ADHD that participated in the planned physical exercise achieved 30.52% better performance than the group of ADHD participants that did not participate in the proposed physical activity.⁶² This same group achieved 40.36% better than the group without ADHD that engaged in the physical exercise.⁶² Overall, this study showed that physical activity improves the attention of children with ADHD and consequently their performance in certain tasks. In another study, a hypothesis was tested in which physical exercise could improve the maintained attention in children with ADHD.⁴⁶ The results of this study

demonstrated that children with ADHD that participate in some sort of physical exercise experienced higher levels of alertness, decreased impulsive behaviors, and increased reaction speed. Research suggests that physical exercise benefits children with ADHD as it helps with their concentration and attention which ultimately helps their learning, and is essential for school performance.⁶²

Physical exercise is a common alternative or complementary treatment for ADHD symptoms because it is low-risk for any complications or side effects. It has been suggested that physical activity is effective in treating impulsive behaviors in these individuals.¹⁷ Yoga exercise is a unique way to guide these children to improve cognitive control, postures, and breathing techniques which as a result can help promote attention, stress management, body awareness and self-control.⁴⁴ Other studies have also supported yoga as an effective treatment for ADHD as they reported favorable outcomes such as reduced inattention, hyperactivity, and anxiety and improved sleep pattern and peer relationships.^{34, 41} The proclaimed benefits of yoga exercise include a significant decline in cortisol levels and increases in brain-derived neurotropic factor (BDNF), serotonin, and dopamine;⁵¹ elevated slow-frequency brain wave activity;⁵ and positive outcomes on heart rate variability, depression, and perceived stress.⁵⁹

In a study of 49 participants, ages 8-12 years of age, diagnosed with ADHD the effect of yoga exercise intervention was determined.¹⁷ The participants were divided into two groups: the yoga exercise group and the control group. The lessons were twice a week for eight weeks, each lesson lasted 40 minutes and was led by a certified yoga instructor. Each session consisted of a 10-minute warm-up followed by a 20-minute yoga activity, which involved improved attention, concentration and balance, and body and breathe awareness. At the end of each session there was a 10-minute cool-down, which included relaxation exercises, flexibility, and balancing.¹⁷ The

results of the study showed that the exercise group showed improvement in reaction time and accuracy rate of both the visual pursuit test and determination test, compared to the control group.

Overall, it has been shown that yoga exercise can be used as an alternative treatment for children with ADHD to reduce inhibition and attention problems.¹⁷ In a meta-analysis study and systematic review it was also shown that “aerobic exercise had a moderate to large effect on core symptoms such as attention, hyperactivity and impulsivity and related symptoms such as anxiety, executive function and social disorders in children with ADHD”.¹⁵ In this same study it was also suggested that Yoga exercise indicates an improvement in the core symptoms of ADHD.

Acupuncture

Acupuncture is one of the most common complementary and alternative medicine (CAM) methods. The mechanism of acupuncture and how it works is still unknown, but it has many benefits compared to conventional medicine such as it is simple, inexpensive, and safe.³⁸ It was shown in a 6-week acupuncture study that the treatment was not effective in improving symptoms of ADHD in children already treated, but it did demonstrate significantly improved cognitive functions and clinical judgement results in patients with untreated ADHD.³⁸

A case study reported the effects and improvements of pharmacological, complementary and alternative medicine including methylphenidate, acupuncture, applied kinesiology, and respiratory exercises on a 9-year old male patient.⁴⁷ The patient reported having sleeping problems and was not improving from just the methylphenidate treatment. Upon examination of the patient muscle weakness due to thoracic breathing was found. To treat the patient respiratory exercises, applied kinesiology, and acupuncture with permanent needles were given. After just

the first treatment the muscle weakness normalized. After the second treatment his sleep patterns improved and after further treatments he showed improvements in his handwriting. The patient's success can most likely be attributed to the synergistic effect of all modalities.

Herbal Medicines

Although pharmaceutical drugs have been found effective in treating symptoms of ADHD, it also creates adverse side effects for patients. Approximately 30% of patients treated with methylphenidate or amphetamine have side effects such as anorexia, abdominal pain, headaches, weight loss, irritability, depressed mood and appetite, and sleep disturbances.³³ The importance of certain minerals such as magnesium, zinc, and iron have been evaluated in ADHD. It has been shown that zinc plays a major role in the behavior of hyperactivity.³⁰ Studies have shown that children with ADHD demonstrated lower serum levels of zinc, magnesium, and iron.^{18, 19, 26} However, more evidence is needed to determine if supplementation of these minerals is an effective treatment option.

Melissa officinalis, an herb also known as lemon balm, was used to treat ADHD symptoms in 120 children.^{3, 43} However, it also contained Ayurvedic and other herbal extracts. The Test of Variables of Attention (TOVA) was given to each participant. The experimental group that was given this herbal treatment showed an increase in the TOVA scores, while the control group showed no changes over time. The difference between the experimental group and the placebo were statistically significant.³ Minor side effects were observed such as insomnia and headache.

Another herb, Valeriana officinalis, was also used in a study to treat ADHD symptoms in 30 participants. As a result, Conner's parent symptom questionnaire (PSQ) indicated a

significant development for both treatment groups compared to the placebo in almost all subscales except conduct problems and psychosomatic problems.³ From the Barkley and DuPaul teacher rating scale, nine of fourteen subscales demonstrated significant improvement after two weeks of treatment.⁹ No serious side effects were reported and the difference between the placebo and experimental group were statistically significant.

Passiflora incarnata, an herb also known as purple passionflower, was studied by Akhondzadeh et al,¹ to better understand the effects of the herb compared to methylphenidate therapy. The participants include 34 children between six and thirteen years old. In the experiment both groups showed compelling clinical outcomes. There were no adverse side effects from the *Passiflora incarnata* treatment method; however, the methylphenidate therapy reported adverse side effects such as anxiety and decreased appetite.

Other herbs that have been tested for their effectiveness in treating children with ADHD are evening primrose oil, Ginkgo biloba, pine bark extract, and St. John's wort. These herbs did not show any significant evidence in their effectiveness for treating ADHD children.³ A modest effectiveness of *Melissa officinalis*, *Valeriana officinalis*, and *Passiflora incarnata* has been observed in the treatment of ADHD symptoms; however, this type of treatment should be considered on an individual basis.

Pharmaceutical Drugs

Pharmaceutical drugs such as methylphenidate have been known to be fairly successful in treating ADHD symptoms; however, they also may cause serious negative side effects such as loss of appetite, sleep disturbances, and mood disorders.⁵⁵ Not only do these medications cause short-term side effects, but the intake of these medications long-term can negatively affect

children and adolescents with ADHD. A major concern for these children taking central stimulants is initial weight loss and ultimately the anorexic effect.⁵⁶ There have been many studies of growth retardation in children with ADHD treated with central stimulants.

Specifically, a study of 410 patients treated with central stimulants for an average of six years focused on determining the major effect of growth retardation from the long-term use of these medications. The results from this study were that (a) patients with ADHD treated with a central stimulant showed a decrease in body weight and height, (b) the decrease in body weight and height eventually stood still after 12-47 months of central stimulant treatment; even after 72 months it was noted that patients still never returned to their normal body weight and height, and (c) doses and z-score decreases were negatively associated.⁵⁶ This study provides significant evidence of growth retardation caused by long-term intake of central stimulants prescribed to children and adolescents with ADHD; however, further clinical studies investigating the impact of growth retardation on the final adult weight and height must be conducted.

Pediatricians, psychiatrists, and parents of children with ADHD should take into account all the possible short-term and long-term side effects these pharmaceutical drugs cause in children and adolescents. Every patient is unique and the treatment suggested for children and adolescents with ADHD should be considered on an individual basis. Physicians and parents should strive to find the best treatment whether it be conventional medicine or complementary and alternative medicine (CAM) or even integrative medicine, which combines both approaches and may provide a more holistic approach.

DISCUSSION

Approximately 12-64% of parents with ADHD children have tried using complementary and alternative medicine (CAM) or therapies.^{16, 38, 39, 71} For pediatricians and psychiatrists it is important for them to understand that this modality is preferred by many parents. Health professionals and parents should be aware of all the treatment options and the possible combination of these treatment options as well. Since every child will differ in their presentation of ADHD, their treatment should be considered individually. For example, one child with ADHD may present with severe symptoms of inattention and hyperactivity. This child may need prescription drugs as a mode of treatment or possibly a combination of different approaches. However, another child with mild symptoms may be able to avoid prescription drugs and instead receive behavioral therapy, exclusively.

Just as each child will present with a different degree of severity of symptoms, each child will also respond differently to treatments. Therefore every patient should be given a distinct treatment plan. Methylphenidate may be effective in some children, but ineffective in others. It may cause side effects in some, but not in others. This applies to all modes of treatment; therefore, the best treatment should be determined by the pediatrician or psychiatrist and the parents together. For more severe levels of ADHD symptoms, combined treatment options or integrative medicine has been suggested as the best treatment plan.^{2, 54}

Healthcare professionals should be open to integrative medicine, as it has been proven that the combination of behavioral therapy and prescription medication positively affects children with ADHD.⁵⁴ Alternative methods of treatment other than prescription drugs can help reduce ADHD symptoms ultimately relying less on medications or even discontinuing their use. Therefore, it is essential for parents and healthcare professionals to be aware of possible

complementary and alternative methods. If children can be given a lower dose of these central stimulants, than it may be possible to reduce some of the side effects. In some cases of ADHD, it is not possible to completely discontinue the use of prescription drugs. However, in cases where alternative methods could be used instead, the use of central stimulants should not be considered or discontinued due to the risk of causing serious side effects.

Lifestyle factors play an important role in the health and treatment of these children and adolescents as well. In a study, it was shown that children with ADHD were twice as likely to have fewer healthy behaviors than children without ADHD.³⁷ The results demonstrated that children with ADHD were less likely to report more than one hour of reading per day, more likely to consume artificial beverages, more likely to report two or more hours of screen time per day and fewer hours of physical activity compared to controls. All these behaviors affect the health of these children. Reading everyday can help offset screen time and actually help with good sleep schedules/practices as well as improve academic success. Television use and screen time seems to be associated with reduced physical activity.³⁷ Physical activity included in the treatment plan has been proven to be important for attention, mood, ADHD symptoms, and the normal development of executive function, as demonstrated in a wide variety of growing research.^{6, 15, 27, 31, 36, 74} In the future, children with ADHD may benefit from improved lifestyle choices.

Other Factors

As there is a vast amount of research regarding this topic, there are other factors that are involved. Some factors include a restricted time frame. Due to these factors additional research was missed that may have been applicable to this study. Also, in some instances the research did

not study the same factors and variables such as the same symptoms of ADHD, making a comparison of all the research more complex. The most obvious contributing factor to this study is that ADHD symptoms and severity vary among individuals. Without a consistent presentation among individuals it is difficult to say exactly which treatment would be most beneficial for all children with ADHD. Instead, this study determined that a combination of the different modes of treatment options presented seemed to be most successful in treating individuals with ADHD. Another limitation is the variety of tests used to determine the improvement of symptoms. For example, one study used the TOVA score while another study used a visual pursuit and determination test. This inconsistency makes comparison difficult and increases the possibility for other confusing factors. This requires further research to determine which test is best in determining the functioning skills in children and adolescents with ADHD, in order to provide a more straight-forward comparison between studies.

In a few of the studies it was mentioned that ADHD can be divided into two different disorders: ADHD-C (or combined type) and ADHD-PI (or predominately inattentive). This warrants for further research specifically in each disorder. Further research will assist in determining other differences between these disorders as well as different ways to treat individuals with one disorder over the other. With further research in the distinct disorders this would allow for an easier comparison of studies.

Another contributing factor in this study was that it included children and adolescents. It would be beneficial to conduct separate research on both groups as symptoms, severity, and treatment may vary between these two groups. Some studies included children up to age 12 years, while others included participants up to 18 years of age. Thus, some of these studies may not be as comparable due to the wide range in age.

CONCLUSION

This study proposed that alternative medicine may be more beneficial for treating children with ADHD; instead of prescription drugs. While the research provided a variety of complementary and alternative methods, in most cases the combination of both Western medicine and CAMs was found to be most successful in treating children with ADHD. However, the combination of these approaches also allows for lower doses of these medications to be administered. Also, it was determined that if the CAM treatment works without the use of prescription drugs than this treatment was recommended because of the fact that central stimulants present a higher risk for a variety of side effects. The alternative treatment options very rarely presented with any side effects.

Thus, the hypothesis was supported by a vast amount of research which suggested that the CAM modalities presented with less or even no side effects at all, while prescription drugs created many side effects and impairments. However, the hypothesis was not as significantly supported in specific research cases of children with severe forms of ADHD, as these individuals benefited more from the combined treatment of both central stimulants and CAM modalities, rather than an alternative treatment to medications.

As more research is conducted on this topic, healthcare workers, specifically pediatricians and psychiatrists, and parents should continue to be mindful and aware of the different approaches to treating children with ADHD. The increased awareness of healthcare professionals will allow them to better understand how to treat the patient and not the disorder and to educate the parents of ADHD children on the variety of treatment options. In this way parents may have a better understanding of the treatment options they have for their child. And,

children with ADHD will receive the best possible treatment for their specific symptoms, so they may have a better quality of life.

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References

1. Akhondzadeh S, Mohammadi M.R, and Momeni F. (2005). Passiflora incarnata in the treatment of attention-deficit hyperactivity disorder in children and adolescents. *Therapy*, 2: pp. 609-614.
2. American Academy of Pediatrics (AAP). (2011). Subcommittee on Attention-Deficit/Hyperactivity Disorder, and Steering Committee on Quality Improvement and Management: ADHD: clinical practice guideline for the diagnosis, evaluation and treatment of attention deficit/hyperactivity disorder in children and adolescents. *Pediatrics*, 128: pp. 1007-1022.
3. Anheyer D, Lauche R, Schumann D, Dobos G, & Cramer H. (2017). Herbal medicines in children with attention deficit hyperactivity disorder (ADHD): A systematic review. *Complementary Therapies in Medicine*, 30, 14-23. Doi:10.1016/j.ctim.2016.11.004
4. Antshel K. M, Faraone S. V, & Gordon M. (2012). Cognitive behavioral treatment outcomes in adolescent ADHD. *Journal of Attention Disorders*, 18(6), 1-13.
5. Arambula P, Peper E, Kawakami M, Gibney K.H. (2001). The physiological correlates of Kundalini yoga meditation: a study of a yoga master. *Applied Psychophysiology and Biofeedback*, 26:147–153.
6. Archer T, Kostrzewa R. M. (2012). Physical exercise alleviates ADHD symptoms: Regional deficits and development trajectory. *Neurotoxicity Research*, 21, 195-209. Doi:10.1007/s12640-011-9260-0.
7. Association for Natural Psychology (2006). Art Therapy. Retrieved from http://www.winmentalhealth.com/arts_therapy.php
8. Badawy A.A, Namboodiri A.M.A, & Moffett J.R. (2016). The end of the road for the tryptophan depletion concept in pregnancy and infection. *Clinical Science (London, England: 1979)*, 130(15), 1327.
9. Barkley RA, Fischer M, Edelbrock CS, Smallish L. (1990). The adolescent outcome of hyperactive children diagnosed by research criteria: I An 8-year prospective follow-up study. *Journal of the American Academy of Child & Adolescent Psychiatry*, 29(4):546-557.
10. Beare R, Adamson C, Bellgrove M.A, Vilgis V, Vance A, Seal M.L, & Silk T.J. (2017). Altered structural connectivity in ADHD: A network based analysis. *Brain Imaging and Behavior*, 11(3), 846. Doi:10.1007/s11682-016-9559-9.
11. Castellanos F.X, Giedd J.N, Eckburg P, Marsh W.L, Vaituzis A.C, Kaysen D, et al. (1994). Quantitative morphology of the caudate nucleus in attention deficit hyperactivity disorder. *American Journal of Psychiatry*, 151(12), 1791–1796.

12. Castellanos F.X, Giedd J.N, Marsh W.L, Hamburger S.D, Vaituzis A.C, Dickstein D.P, et al. (1996). Quantitative brain magnetic resonance imaging in attention-deficit hyperactivity disorder. *Archives of General Psychiatry*, 53(7), 607–616.
13. Castellanos F.X, Lee P.P, Sharp W, Jeffries N.O, Greenstein D.K, Clasen L.S, et al. (2002). Developmental trajectories of brain volume abnormalities in children and adolescents with attention-deficit/hyperactivity disorder. *Jama-Journal of the American Medical Association*, 288(14), 1740–1748.
14. Catalá-López F, Hutton B, Núñez-Beltrán A, Mayhew A, Page A. D, Ridao M. J, Moher M, et al. (2015). The pharmacological and non-pharmacological treatment of attention deficit hyperactivity disorder in children and adolescents: Protocol for a systematic review and network meta-analysis of randomized controlled trials. *Systematic reviews*, 4(1):19. Doi: 10.1186/s13643-015-0005-7.
15. Cerrillo-Urbina A.J, García-Hermoso A, Sánchez-López M, Pardo-Guijarro M.J, Santos Gómez J.L, Martínez-Vizcaíno V. (2015). The effects of physical exercise in children with attention deficit hyperactivity disorder: A systematic review and meta-analysis of randomized control trials: Exercise and attention deficit hyperactivity disorder. *Child: Care, Health and Development*, 41(6):779-788. Doi: 10.1111/cch.12255.
16. Chan E. (2008). Quality of efficacy research in complementary and alternative medicine. *JAMA: The Journal of the American Medical Association*, 299: pp. 2685-2686
17. Chou C., & Huang C. (2017). Effects of an 8-week yoga program on sustained attention and discrimination function in children with attention deficit hyperactivity disorder. *Peerj*, 5, e2883. Doi:10.7717/peerj.2883.
18. Cortese S, Angriman M, Lecendreux M, Konofal E. (2012). Iron and attention deficit/hyperactivity disorder: What is the empirical evidence so far? A systematic review of the literature. *Expert Review of Neurotherapeutics*, 12:1227–40.
19. Curtis L.T, Patel K. (2008). Nutritional and environmental approaches to preventing and treating autism and attention deficit hyperactivity disorder (ADHD): A review. *Journal of Alternative and Complementary Medicine*, 14:79–85.
20. Erhardt S, Schwieler L, Imbeault S, Engberg G. (2017). The kynurenine pathway and schizophrenia. *Neuropharmacology*, 112, pp. 389-398.
21. Evangelisti M, De Rossi P, Rabasco J, Donfrancesco R, Lionetto L, Capi M, Villa M.P. (2017). Changes in serum levels of kynurenine metabolites in paediatric patients affected by ADHD. *European Child & Adolescent Psychiatry*, 26(12), 1433-1441. Doi:10.1007/s00787-017-1002-2.

22. Evans S.W, Owens J.S, and Bunford N. (2014). Evidence-based psychosocial treatments for children and adolescents with attention-deficit/hyperactivity disorder. *Journal of Clinical Child & Adolescent Psychology*, 43: pp. 527-551.
23. Fibert P, Relton C, Heirs M, Bowden D. (2016). A comparative consecutive case series of 20 children with a diagnosis of ADHD receiving homeopathic treatment, compared with 10 children receiving usual care. *Homeopathy*, 105(2):194-201. Doi: 10.1016/j.homp.2015.09.008.
24. Filipek P. A, SemrudClikeman M, Steingard R. J, Renshaw P. F, Kennedy D. N, & Biederman J. (1997). Volumetric MRI analysis comparing subjects having attention-deficit hyperactivity disorder with normal controls. *Neurology*, 48(3), 589–601.
25. Fischer M, Barkley R.A, Fletcher K.E, Smallish L. (1993). The stability of dimensions of behavior in ADHD and normal children over an 8-year follow up. *Journal of Abnormal Child & Psychology*, 21(3):315-337.
26. Gao Q, Liu L, Qian Q, Wang Y. (2014). Advances in molecular genetic studies of attention deficit hyperactivity disorder in China. *Shanghai Archives of Psychiatry*, 26:194–206.
27. Gapin J, Etnier J.L. (2010). The relationship between physical activity and executive function performance in children with attention-deficit hyperactivity disorder. *Journal of Sport & Exercise Psychology*, 32, 753-763.
28. Gerdes A.C, Hoza B, Pelham W.E. (2003). Attention-deficit/hyperactivity disordered boys' relationships with their mothers and fathers: Child, mother, and father perceptions. *Development and Psychopathology*. 15(02):363-382.
29. Giedd J.N, Castellanos F.X, Casey B.J, Kozuch P, King A.C, Hamburger S.D, et al. (1994). Quantitative morphology of the corpus-callosum in attention-deficit hyperactivity disorder. *American Journal of Psychiatry*, 151(5), 665–669.
30. Golub M.S, Takeuchi P.T, Keen C.L, Hendrickx A.G, Gershwin M.E. (1996). Activity and attention in zinc-deprived adolescent monkeys. *American Journal of Clinical Nutrition*, 64:908–15.
31. Guiney H, Machado L. (2013). Benefits of regular aerobic exercise for executive functioning in healthy populations. *Psychonomic Bulletin & Review*, 20, 73-86. Doi:10.3758/s13423-012-0345-4.
32. Habib H.A, & Ali U. (2015). Efficacy of art therapy in the reduction of impulsive behaviors of children with ADHD co-morbid intellectual disability. *Pakistan Journal of Psychology*, 46(2).

33. Hariri M, Azadbakht L. (2015). Magnesium, iron, and zinc supplementation for the treatment of attention deficit hyperactivity disorder: A systematic review on the recent literature. *International journal of preventive medicine*, 6(1):83. Doi: 10.4103/2008-7802.164313.
34. Harrison L.J, Manocha R, Rubia K. (2004). Sahaja yoga meditation as a family treatment for children with attention deficit-hyperactivity disorder. *Clinical Child Psychology and Psychiatry*, 9:479–497. Doi: 10.1177/1359104504046155.
35. Henley D. (1998). Art therapy in a socialization program for children with attention deficit hyperactivity disorder. *American Journal of Art Therapy*, 37(1), 2-11.
36. Hillman, C.H. (2014). I. An introduction to the relation of physical activity to cognitive and brain health, and scholastic achievement. *Monographs of the Society for Research in Child Development*, 79(4), 1-6.
37. Holton K.F, & Nigg J.T. (2016). The association of lifestyle factors and ADHD in children. *Journal of Attention Disorders*, Doi: 10.1177/1087054716646452.
38. Hong S, Cho S. (2016). Treating attention deficit hyperactivity disorder with acupuncture: A randomized controlled trial. *European Journal of Integrative Medicine*, 8:150-157.
39. Hunt K, and Ernst E. (2011). The evidence-base for complementary medicine in children: a critical overview of systematic reviews. *Archives of Disease in Childhood*, 96: pp. 769-776.
40. Hynd G.W, SemrudClikeman M, Lorys A, Novey E.S, & Eliopoulos D. (1990). Brain morphology in developmental dyslexia and attention deficit disorder hyperactivity. *Journal of Clinical and Experimental Neuropsychology*, 12(1), 62–63.
41. Jensen P.S, Kenny D.T. (2004). The effects of yoga on the attention and behavior of boys with attention-deficit/hyperactivity disorder (ADHD). *Journal of Attention Disorders*, 7:205–216. Doi: 10.1177/108705470400700403.
42. Johnston C, Mash E.J. (2001). Families of children with attention-deficit/hyperactivity disorder: Review and recommendations for future research. *Clinical Child and Family Psychology Review*, 4(3): 183-207.
43. Katz M, Levine A.A, Kol-Degani H, and Kav-Venaki L. (2010). A compound herbal preparation (CHP) in the treatment of children with ADHD: a randomized controlled trial. *Journal of Attention Disorders*, 14: pp. 281-291.
44. Kimbrough S, Balkin R, Rancich A. (2007). The effect of inverted yoga positions on short-term memory. *The Online of Sport Psychology*, 9:34–42.

45. Krain A.L, & Castellanos F.X. (2006). Brain development and ADHD. *Clinical Psychology Review*, 26(4), 433–444. Doi:10.1016/j.cpr.2006.01.005.
46. Medina J.A, Netto T.L, Muszkat M, Medina A.C, Botter D, Orbetelli R, et al. (2010). Exercise impact on sustained attention of ADHD children, methylphenidate effects. *ADHD Attention Deficit and Hyperactivity Disorders*, 2(1): 49–58. Pmid: 21432590.
47. Molsberger F, Raak C, Witthinrich C. (2014). Improvements in sleep and handwriting after complementary medical intervention using acupuncture, applied kinesiology, and respiratory exercises in a nine-year-old ADHD patient on methylphenidate. *Explore (New York, N.Y.)*, 10(6):398-403. Doi: 10.1016/j.explore.2014.08.006.
48. Mostofsky S.H, Reiss A.L, Lockhart P, & Denckla M.B. (1998). Evaluation of cerebellar size in attention-deficit hyperactivity disorder. *Journal of Child Neurology*, 13(9), 434–439.
49. Mostofsky S.H, Cooper K.L, Kates W.R, Denckla M.B, & Kaufmann W.E. (2002). Smaller prefrontal and premotor volumes in boys with attention-deficit/hyperactivity disorder. *Biological Psychiatry*, 52(8), 785–794.
50. Mous S.E, White T, Muetzel R.L, Marroun H.E, Rijlaarsdam J, Polderman T.J.C, Tiemeier H. (2017). Cortical morphology as a shared neurobiological substrate of attention-deficit/hyperactivity symptoms and executive functioning: A population-based pediatric neuroimaging study. *Journal of Psychiatry and Neuroscience*, 42(2), 103-112. Doi:10.1503/jpn.150371.
51. Pal R, Singh S.N, Chatterjee A, Saha M. (2014). Age-related changes in cardiovascular system, autonomic functions, and levels of BDNF of healthy active males: role of yogic practice. *Age*, 36(4):9683. Doi: 10.1007/s11357-014-9683-7.
52. Pelham W.E. Jr, Fabiano G.A. (2008). Evidence-based psychosocial treatments for Attention-Deficit/Hyperactivity Disorder. *Journal of Clinical Child Adolescent Psychology*, 37(1):184-214.
53. Pfiffner L.J, & Haack L.M. (2014). Behavior management for school-aged children with ADHD. *Child and Adolescent Psychiatric Clinics of North America*, 23(4), 731.
54. Pfiffner L.J, and Haack L.M. (2014). Nonpharmacological treatments for childhood ADHD and their combination with medication. In Nathan P.E., and Gordon J.M. (eds): A guide to treatments that work, 4th edition. *New York: Oxford University Press*.
55. Pliszka S. (2007). Practice parameter for the assessment and treatment of children and adolescents with attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, 46:894–921.

56. Powell S.G, Frydenberg M, & Thomsen P.H. (2015). The effects of long-term medication on growth in children and adolescents with ADHD: An observational study of a large cohort of real-life patients. *Child and Adolescent Psychiatry and Mental Health*, 9, 50.
57. Ross S.M. (2015). Valerian root and lemon balm extracts: A phytomedicine compound improves symptoms of hyperactivity, attention deficits, and impulsivity in children. *Holistic Nursing Practice*, 29(6):391-395. Doi: 10.1097/HNP.000000000000118.
58. Safran D.S. (2002). Art Therapy and ADHD diagnostic and therapeutic approaches. Jessica Kingsley, London.
59. Satin J.R, Linden W, Millman R.D. (2014). Yoga and psychophysiological determinants of cardiovascular health: comparing yoga practitioners, runners, and sedentary individuals. *Annals of Behavioral Medicine*, 47:231–241. Doi: 10.1007/s12160-013-9542-2.
60. Schwarcz R, & Stone T.W. (2016). The kynurenine pathway and the brain: Challenges, controversies and promises. *Neuropharmacology*, Doi:10.1016/j.neuropharm.2016.08.003.
61. Seidman L.J, Valera E.M, & Makris N. (2005). Structural brain imaging of attention-deficit/hyperactivity disorder. *Biological Psychiatry*, 57(11), 1263–1272. Doi:10.1016/j.biopsych.2004.11.019.
62. Silva A.P, Prado S.O.S, Scardovelli T.A, Boschi Silvia R.M.S, Campos L.C, & Frère A.F. (2015). Measurement of the effect of physical exercise on the concentration of individuals with ADHD. *PloS One*, 10(3), e0122119. Doi:10.1371/journal.pone.0122119.
63. Sowell E.R, Thompson P.M, Welcome S.E, Henkenius A.L, Toga A.W, & Peterson B.S. (2003). Cortical abnormalities in children and adolescents with attention-deficit hyperactivity disorder. *Lancet*, 362(9397), 1699–1707. Doi:10.1016/S0140-6736(03)14842-8.
64. Sprich S.E, Burbridge J, Lerner J.A, & Safren S.A. (2015). Cognitive-behavioral therapy for ADHD in adolescents: Clinical considerations and a case series. *Cognitive and Behavioral Practice*, 22(2), 116-126. Doi:10.1016/j.cbpra.2015.01.001.
65. Stolberg V.B. (2017). ADHD Medications: History, Science, and Issues. Santa Barbara, California: *Greenwood*, an imprint of ABC-CLIO, LLC.
66. Svatkova A, Nestrasil I, Rudser K, Goldenring Fine J, Bledsoe J, & Semrud-Clikeman M. (2016). Unique white matter microstructural patterns in ADHD presentations-a diffusion tensor imaging study: Microstructural WM differences between ADHD presentations. *Human Brain Mapping*, 37(9), 3323-3336. Doi:10.1002/hbm.23243.

67. Szekely E, Sudre G.P, Sharp W, Leibenluft E, & Shaw P. (2017). Defining the neural substrate of the adult outcome of childhood ADHD: A multimodal neuroimaging study of response inhibition. *American Journal of Psychiatry*, 174(9), 867-876. Doi:10.1176/appi.ajp.2017.16111313.
68. The perfect storm: Live pure chiropractic utilizes insight technology to provide solutions and hope to help pediatrics with autism, ADHD & sensory challenges. *ICT Monitor Worldwide*. 2016.
69. Thomas R, Sanders S, Doust J, Beller E, Glasziou P. (2015). Prevalence of attention-deficit/hyperactivity disorder: a systematic review and meta-analysis. *Pediatrics*, 135(4):e994-1001.
70. Ueland P.M, Ulvik A, Rios-Avila L, Middtun Ø, & Gregory J.F. (2015). Direct and functional biomarkers of vitamin B6 status. *Annual Review of Nutrition*, 35(1), 33-70. Doi:10.1146/annurev-nutr-071714-034330.
71. Weber W, and Newmark S. (2007). Complementary and alternative medical therapies for attention-deficit/hyperactivity disorder and autism. *Pediatric Clinics of North America*, 54: pp. 983-1006
72. Weick R. (2014). Improving patient health through the brain. *Grand Rapids Business Journal*, 32:3.
73. Wilens T.E, McBurnett K, Bukstein O, McGough J, Greenhill L, Lerner M, Lynch J.M. (2006). Multisite controlled study of OROS Methylphenidate in the treatment of adolescents with attention-deficit/hyperactivity disorder. *Archives of Pediatric and Adolescent Medicine*, 160, pp. 82-90.
74. Ziereis S, Jansen P. (2015). Effects of physical activity on executive function and motor performance in children with ADHD. *Research in Developmental Disabilities*, 38, 181-191. Doi:10.1016/j.ridd.2014.12.005.