CASE STUDY

Improvement in ADHD Symptomatology Following Chiropractic in a 5-Year-Old Male: A Case Report & Review of the Literature

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Abstract

Objective: This paper presents a case study of improved ADHD symptomatology for a child undergoing chiropractic care.

Clinical Features: A 5-year-old male presented to a chiropractic office for examination and history for the detection of vertebral subluxation. Thermal scanning and sEMG were utilized and it was determined that vertebral subluxations were present in conjunction with spinal tension, postural faults, and reduced range of motion in the cervical spine.

Intervention and Outcomes: The patient received a total of 54 adjustments in the upper cervical, thoracic, lumbar, and sacral regions over six months of care. Thermography and sEMG scans were performed at the initial visit and at two re-assessments. Patient progress was also monitored subjectively as the mother noted improvements in behavior. Instrumentation revealed improvement in symmetry and pattern.

Conclusions: The results of this case study reveal an overall positive outcome of ADHD symptomatology following chiropractic care.

Key Words: *Chiropractic, vertebral subluxation, Diversified, adjustment, ADHD, behavioral issues, sEMG, thermography*

Introduction

Attention Deficit Hyperactivity Disorder, often referred to as ADHD, is the most widely diagnosed neurodevelopmental disorder in childhood. It is comprised of three forms: inattention (ADHD-I), hyperactivity combined with impulsiveness (ADHD-H), or inattention paired with hyperactivity (ADHD-C).[1] 5.4 million, or 9.4%, of children from 6 to 17 years of age have been diagnosed with this condition in the United States.[2]

Annual rates of diagnosis continue to increase from 3% annually between 1997-2006 to an average of 5.5% annually between 2003-2007.[3] ADHD is a complex and difficult condition to diagnose as behavior and symptomatology must be present in settings outside the physician's office, such as the home and/or school. Moreover, children with ADHD typically present with comorbid conditions such as: learning disabilities, behavioral issues, anxiety, and depression.[2]

These issues may manifest as difficulty focusing, constant desire to be moving and not sitting still, being impatient, or easily distracted.[4] These conditions must alter a child's functional capability, including the academic realm and social circles.[2]

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Practitioners are also advised to use the DSM (Diagnostic and Statistical Manual of Mental Disorders) criteria for diagnosis which includes statements made by parents and teachers alongside six or more symptoms relating to inattention, hyperactivity, and impulsivity, all of which must be present by age seven. [5,6]

Etiology

Causal factors for ADHD have been widely disputed. Some argue that genetic factors play an important role in the development of ADHD, while others argue that pre and perinatal health/risks, psychosocial factors, and toxic environmental elements, or a combination thereof, are to blame. It is important to note that those who are first degree relatives to individuals with ADHD are two to eight times more likely to be diagnosed with ADHD than those whose family members do not have said condition. Thus, whole genome and rare chromosomal variants have been studied as potential causes of ADHD.

Whole genome studies appear very appealing as they can lead to a greater understanding of potential biological risk pathways. However, some researchers argue that rare genetic variants of a smaller scale provide greater detail and poignant understanding for the etiology of ADHD. Furthermore, whole genome studies have been fairly unremarkable as statistical thresholds have not been reached due to a high testing burden.

In other words, 500,000 to 1 million genetic variants have been researched in recent studies, which does not allow for compartmentalization of individual genetic factors that may lead to the development of ADHD. Thus, researchers are looking to rare genetic variants for possible understanding. 22q11 microdeletion syndrome has long been shown to increase risk of ADHD and psychosis, but recently structural or copy number variants (CNVs) have become even more important to understanding.

While every individual has structural or copy variants, those with brain disorders, such as ADHD, are thought to have large and rare CNVs that could play a role in the development of this condition. These CNVs also have a close association to other neuropsychological disorders such as autism and schizophrenia. Ultimately, further research must be attained to validate the importance and consequence of CNVs in an individual.

Maternal smoking and stress during pregnancy along with maternal alcohol use during pregnancy, low birth weight and low APGAR scores, are other causal factors to consider.[5,7] While it may appear obvious that these factors could enhance the likelihood of childhood ADHD, it is critical to note that there has not been a positive correlation in recent years between decreased maternal smoking and decreased prevalence of children with ADHD.[7]

It has also been observed that children born prior to 26-weeks gestation are four times more likely to be diagnosed with attention deficit hyperactivity disorder.[8] Similar to the speculation surrounding genetic factors, maternal smoking and excess stress have not been formally proven as causal factors for the development of attention deficit hyperactivity disorder and require further research to validate such claims.[7]

It is widely observed that 70-80% of children diagnosed with ADHD perform poorly in the academic setting. These deficits relate to executive dysfunction, such as inhibitory control, inadequate planning skills, and issues with following directions. Children diagnosed with ADHD also display low verbal and nonverbal IQ (Intelligence Quotient) scores, and difficulty forming concepts and lack visuospatial skillsets. These wide ranging deficits exhibited by children with ADHD can be attributed to inadequacies within various brain systems.

One pertinent model to explain ADHD relates to the prefronto-striatal model. In this model, the prefrontal cortex and striatopallidal systems are involved. The striatopallidal system is comprised of the following structures: dorsal striatum, dorsal pallidum, ventral striatum, and the ventral pallidum.[9] The role of the striatum in the brain is to synthesize information that travels from the pre-frontal cortex. This information relates to organization and planning behavior, both of which are lacking in those who have ADHD.[10]

In this model, it is thought that control deficits are present, causing a lack of inhibition. This issue with inhibition is paired with altered shape and function of the structures within the striatopallidal system. However, it has been argued that this model cannot be responsible for all of the cognitive deficits exhibited by children with ADHD. It appears that different studies have generated varying results as to abnormal brain function and structure. For instance, functional neuroimaging studies have depicted decreased activity in neural pathways within different brain regions.

Lowered activation during attention tasks in ADHD patients was discovered in the left prefrontal cortex, temporal regions, anterior cingulate cortex, the thalamus and striatum of the right-hemisphere, and left occipital areas. Clearly these results are much different than the proposed prefronto-striatal model. Electroencephalographic (EEG) studies have observed decreased frontal theta waves, and decreased wave activity in the occipital and parietal regions of the brain.

These discrepancies have been attributed to the different forms of ADHD (inattentive, hyperactive/impulsive, inattention/hyperactivity).[9] Not only has altered brain activity within various brain structures been reported in the literature, but global efficiency and shortest path mechanisms have also been studied. Global efficiency is defined as the speed that information travels within the brain. It has been shown to be decreased in patients with ADHD, leading to decreased processing functional capacity and decreased overall function of the brain. Shortest path length relates to the ability of the brain to transfer information appropriately.

The shortest path length is used to understand the integration capacity of the brain, with shorter pathways a marker for normal brain function. Individuals with ADHD have been shown to have increased length in the pathways. Thus, those with ADHD have decreased ability to process information and the processing takes more time than the normal/control brain.[4]

Other observations regarding brain structure and ADHD have been identified. These include: decreased global brain volume,

decreased grey matter in frontostriatal circuits, atypical white matter formation, cortical thinning, and delayed cortical development. As a result, the etiology of ADHD has global implications such as abnormal structural/functional brain regions and abnormal neural circuits.[8] It is extremely difficult to pinpoint the exact pathogenesis of this condition, but it is evident that monitoring brain activity, function, and morphology is valuable for further understanding.

When deciphering causes of ADHD, it is imperative to identify the item being studied as either a true causative factor or simply a complicating factor to the myriad of biochemical and psychosocial factors that influence the development of ADHD. Additional research is vital for the further understanding of the most commonly diagnosed childhood neurodevelopmental disorder.

Sequellae

Attention deficit hyperactivity disorder is most commonly found in young populations, but symptoms can improve/resolve with age. It is estimated that 2.5% of the adult population still exhibits diagnosable symptoms of ADHD.[8,9] Other estimates state that 3-4% of adults have ADHD and that approximately 50% of childhood ADHD cases persist to adulthood. This can greatly impede the normal functioning of adults as many adults may have academic, social, work and family-related functional difficulties. ADHD is associated with other conditions such as: mood, anxiety, substance abuse, and personality disorders.

Greater emphasis has been placed on brain morphology and function in children with ADHD, but is much less prevalent for adults with ADHD. As mentioned, adults with ADHD are susceptible to emotional instability and impulsivity. The amygdala is greatly involved in emotional processes, namely fear, negative experiences, and emotional stimuli. The hippocampus is involved in motivation, emotion, learning, and memory.

One study compared the sizes of the amygdala and hippocampus in adults with ADHD compared to those with major depression. A healthy control group was also included. It was confirmed that adult patients with ADHD had smaller amygdalas than the comparative groups. This may conclude that smaller amygdala volumes can lead to frequent emotional changes and lack of emotional control. Differences in hippocampal volume between each test group was unremarkable.[11]

It is apparent that pervading symptoms of ADHD can make adolescence and adulthood incredibly challenging. Conventional and nonconventional treatments will be discussed in the next section, as such treatments may help alleviate the emotional instability, hyperactivity, and functional deficits common to both children and adults with ADHD.

Conventional Treatment

Pharmacotherapy is a common treatment modality for children with ADHD with moderate to severe levels of impairment.[8] It has been discussed previously that fronto-striato-cerebellar neurological circuits may be defective in those with ADHD. Dopamine (DA) and noradrenaline (NA), both catecholamines, are important components for brain function, specifically acting within the fronto-striato-cerebellar circuits. Thus, inadequate levels or impaired function of these catecholamines may help explain the decreased brain function as expressed in ADHD patients. However, the exact neurobiological pathways regarding ADHD and its treatment are not well understood.[12]

Methylphenidate (MPH, also known as Ritalin) is most commonly prescribed for children with moderate to severe ADHD, followed by Dextroamphetamine (D-AMPH).[8] The role of methylphenidate is to increase extrasynaptic levels of DA and NA by blocking the body's reuptake mechanism. Dextroamphetamine aims to do the same, but by a combination of reuptake inhibition and increased release. This medication is also capable of protecting dopamine and noradrenaline from monoamine oxidase, which breaks down these neurotransmitters.[12]

A patient information sheet released by The Brown University Child & Adolescent Psychopharmacology Update explains the various types of methylphenidate (Ritalin). This update depicts 3 formulations of this drug: immediate release (IR), sustained release (SR), and extended-release (ER). There is also Ritalin LA which is a combination of IR/ER formulation. Common side effects of this medication include: nervousness, insomnia, loss of appetite, abdominal pain, weight loss, and tachycardia.[13]

It is reported that approximately 70% of children utilizing psychostimulant therapy, such as the use of Ritalin, show improvement in symptoms. However, the side effects may outweigh the benefits of using this drug. Parental concerns regarding drug therapy is one reason that alternative, or nonconventional treatments for ADHD are utilized in up to 64% of cases. The following section will describe these alternative treatments as they relate to individuals with ADHD.[14]

Complementary and Alternative Therapies (CAM)

Various alternative methods have been used to treat and minimize symptoms associated with ADHD. The first alternative therapy to discuss relates to herbs. Commonly utilized herbs include: ginko biloba, chamomile, kava kava, and valerian, for their properties that aid restlessness, decreased concentration, and sleep problems.

One study by Li et al. performed a randomized control trial to understand the efficacy, safety, and mechanism by which Nindong granule (NDG) could impact children with ADHD as opposed to Ritalin. The conclusion was that NDG was an alternative form of short term treatment in comparison to methylphenidate. Furthermore, Sinn performed a review of clinical trials to understand the effects that omega-3 (n-3) fatty acids, as well as minerals, Pyncogenol (herb), and food colors had on the behavior and learning capacity for children with ADHD.

The author concluded that strong evidence supported the use of omega-3 fatty acid supplementation and that food colorings

offered negative effects for children with this condition.[15] Furthermore, a review article by the Alternative Medicine Review noted that deficiencies of zinc, magnesium, glutathione, and/or omega-3 fatty acids have been linked to issues in children with ADHD such as difficulty with concentration, memory, and learning. Poor diet and deficiencies of these nutrients contributes to oxidative stress and neuronal plasticity changes, resulting in the issues described.

Another suggested dietary modification relates to amino acid supplementation. Many amino acids are important precursors to various neurotransmitters, such as phenylalanine, tyrosine, and tryptophan, all of which have been found in low levels in the blood of adults and children with ADHD. Addressing and correcting metabolic imbalances may be necessary for those with deficiencies. Additionally, refined carbohydrates and sugar can lead to deficient learning ability and increased negative behaviors in children with ADHD and should therefore be addressed.

Aside from dietary and herbal recommendations, it has been suggested that exercise is a valuable asset for those with ADHD. Physical exercise enhances brain activity and aids neurotransmitter systems. This can lead to improved memory, concentration, learning, and mood, all of which are beneficial for ADHD patients.[16]

Given the multi-faceted nature of ADHD, it has been recommended by Kidd that an integrative approach creates the best results in children suffering from ADHD. Kidd advise the removal of food additives, sensitizing foods, and sugar. The author also advises allergy assessments, nutrient deficiency assessments, and intolerances to foods and chemicals. Toxicity from metals should also be analyzed and addressed.

In the end, if CAM researchers and practitioners want CAM therapies to be a viable option for the treatment and management of ADHD, then additional research and scrutiny is critical.[15]

Case Report

History

The patient is a 5-year-old male who presented to the chiropractic office with his mother as a result of a pending ADHD diagnosis. The mother stated that she wanted to explore non-medical treatment options and understand the causation behind her child's behavior. The child was described as "out of control" and exhibited a constant urge to bounce and jump. Upon further discussion, it was noted that the child had a history of ear infections and was fed formula after two weeks of breastfeeding. In addition, neurodevelopmental delays were present as the child skipped crawling during his developmental progression and currently exhibited toe walking.

Chiropractic Examination

A chiropractic examination was performed utilizing passive range of motion, motion and static palpation, visual observation, paraspinal thermography, and static EMG scanning to evaluate for the presence of vertebral subluxation. Cervical range of motion was heavily restricted in the upper cervical spine as a result of passive movement. No motion palpation listings were recorded at the initial examination visit, but tension within the patient's spine and postural faults were listed as concurrent findings.

Instrumentation readings were taken using the Millennium Model of the CLA Insight and 2nd generation thermal scan. Paraspinal thermography illustrated a severe deviation to the left at the C1 vertebral level. The remaining spinal regions were evaluated and demonstrated to be within normal limits with regards to temperature asymmetry.

Furthermore, static EMG scans were performed and revealed severe readings to the left of the C1, C7, and T1 vertebral levels as well as to the right of the C3, C5, C7, T1, and L5, S1 vertebral segments. Moderate readings were present to the left of the C3 and C5 levels, and to the right of the L1 segment. Mild readings were present bilaterally at the level of T8.

Pattern, symmetry, and total energy values were given with each scan and were 55.93, 73.01, and 288.79 at first visit, respectively. The patient's thermographic and sEMG initial readings were monitored over the course of treatment at each reassessment. More information regarding thermography and sEMG is found in the discussion section of this paper.

The diagnosis of vertebral subluxation present at C1 and C2 was made as a result of exam findings, including instrumentation and palpation findings, as well as motion restriction of these segments at the first adjustment visit.

Intervention

The patient's mother consented to chiropractic care in which the doctor utilized high velocity, low amplitude thrusts as defined by Diversified Technique. The initial treatment plan was scheduled as follows: three visits per week for the first eight weeks, then two visits per week for the next 10 weeks, one time per week for the following eight weeks, and one time per month thereafter.

At the first visit, C1 and C2 were adjusted using Diversified Technique. An index finger contact was utilized at the transverse process of atlas with a lateral to medial thrust during the adjustment. Moreover, the spinous process of C2 was contacted with the doctor's index finger with a posterior to anterior, inferior to superior, and lateral to medial thrust applied. The patient was supine during these adjustments.

The majority of the patient visits addressed subluxations at C1 and C2. However, subluxations in the thoracic, lumbar, and sacral regions were also addressed. All thoracic adjustments were performed anteriorly, with the doctor's thenar eminence and interspace between the proximal and distal metacarpal phalangeal joints contacting either side of the spinous process of the restricted thoracic segment.

An inferior to superior tissue pull was made to secure the contact and an anterior to posterior thrust was applied as the patient is rolled from his side to his back. All lumbar and sacral adjustments are performed in a side posture position. In

the lumbar region, the doctor contacts the mammillary or spinous process of the segment with his pisiform and the opposite hand is used for stabilization at the patient's elbow. Sacral adjustments are performed in the same manner, but the S2 tubercle was contacted instead.

Outcomes

Patient progress was evaluated using sEMG and paraspinal thermography at each re-assessment, as well as subjective measures at each office visit. Visible changes were noted in the sEMG scans as less severe and more mild and moderate readings were present as care progressed. Pattern and symmetry values fluctuated over the course of care, but generally improved. Thermography readings also improved as all subsequent scans after the initial visit revealed temperatures denoted as within normal limits. See discussion section and Figures 1 and 2 for more information regarding sEMG and thermography values, interpretation, and validity.

Patient progress was also assessed via subjective outcomes from the mother of the patient and it was noted whether the patient's symptomatology and/or behavior had changed from the previous visit. No changes in behavior were recorded until the 14th visit. At this time, the mother stated that the patient's teacher had informed her that the patient elicited behavioral changes and that he was becoming more focused with fewer disruptions in class.

On the 16th visit to the office, the mother reported that they had a family party at their home and the patient was very cooperative. Normally at family gatherings, the patient would be reprimanded for behavior issues constantly. However, the patient was not stressed and/or hyperactive, but was talking with relatives, playing with the other kids, and enjoyed the company.

The mother was very pleased with such progress. The child made other improvements at the 19th and 48th office visits. The child wrote a written letter by himself, a task that he could not previously accomplish. He was also improving in focus, listening skills, and sitting in his chair without fidgeting.

Discussion

Diversified Technique

Diversified Technique, or DT, is considered the most generic of all technique systems. As its name implies, this technique is subject to various interpretations, as its scope is rather broad. In fact, 92% of chiropractors in the United States and Canada claim to utilized this technique.[17]

Diversified chiropractors, as claimed by Cooperstein, are subluxation-based and attempt to remove subluxation via patient history, palpation, x-ray, thermography, leg checks, as well as reflex procedures. DT practitioners prefer palpation as an examination procedure. The adjustments delivered by the chiropractor are not limited to a set protocol as extremity adjustments are accepted within Diversified Technique, as well as high and low velocity adjustments, various pieces of equipment (drop or flexion-distraction tables or padded wedges) and adjusting instruments. It is important to understand that DT practitioners are also categorized as full-spine doctors, implying that adjustments are not region-specific, as seen in upper cervical techniques and other protocols. Once the adjustment(s) is/are made over the course of patient care, outcomes are assessed via examination findings. The goal is to eliminate positive examination findings by the patient's re-assessment date(s).[18]

Paraspinal Thermography

The use of diagnostic instrumentation, such as paraspinal thermography, is often used by chiropractors in conjunction with symptomatology, static and/or motion palpation, posture analysis, leg length analysis, tenderness in the spinal region, and abnormal muscle tone, to evaluate for the presence of subluxation. The premise of thermography is based on 3 physiological principles which are summarized below:

1. Skin temperature reflects autonomic function.
2. Small variations in skin temperature over time implies that the autonomic nervous system is functioning and adapting appropriately as the environment changes.
3. Normal or abnormal adaption to the environment can be estimated through the comparison of consecutive skin temperature measurements.[19]

The autonomic nervous system controls the organs, glands, and blood vessels that act as regulators of temperature for an individual as their external environments change. In a healthy patient, skin temperature changes as the environment changes, but symmetry will be present across various regions of the body.[20]

In a subluxated patient, there is autonomic dysfunction in addition to joint motion restriction, muscle contraction, vasomotor changes, and tenderness. Static thermographic findings appear on the patient's scans. In other words, multiple scans recorded over several hours for the purpose of "pattern analysis" demonstrates similar or identical temperature findings.

Spinal manipulation is warranted at this time with the logic that autonomic dysfunction is present. However, it is important to consider both the reliability of thermography to detect temperature changes, as well as understanding the ability of clinicians to accurately interpret paraspinal thermography results in order to appropriately warrant the use of spinal manipulation.[19]

Several studies have examined the intra- and inter-examiner reproducibility of thermal scanning instruments. These studies vary in their qualifications of reproducibility, ranging from weak, moderate-to-good, and good-to-excellent. Spector et al. found reproducibility to be .940 to .995 among twelve scanned subjects at multiple spinal levels in various patient positions.

DeBoer et al. incorporated three examiners and twenty-four test subjects for inter- and intra-examiner reproducibility which was found to be moderate-to-good. The Tytron C-3000 was utilized in a study by Owens et al. which included two examiners and thirty subjects. The authors proposed that

alterations in thermal scans are physiological in nature and not a result of equipment malfunction. Furthermore, Keating et al. concluded that weak levels of inter-examiner agreement existed in their study of lumbar analysis in 25 asymptomatic and 21 symptomatic test subjects.

A study conducted by McCoy et al. had one hundred students participate over a 4-week time period. Two Insight Rolling Thermal Scanners were utilized by two clinicians with a baseline of 5 years' experience with these scanners. The examiners scanned the subjects from S1 to C1 vertebral levels without access to data collection. The results displayed excellent inter- and intra-examiner reproducibility for paraspinal thermal scanning. It is important to note that this is the largest study conducted in the literature to date. This study also confirmed the findings of Owens et al., asserting that changes visualized in properly performed scans are the result of physiologic change, not technical or equipment error.[20] The conclusion of this study as well as a 2015 study by Mansholt et al. state that the influence of thermographic findings on the utilization of spinal manipulation is lacking in the literature.[19,20]

Static EMG (sEMG)

Electromyography is the recording of the electrical activity that is associated with skeletal muscle function.[21] This electrical current pattern is an important tool to understanding how the body is functioning. The muscles on both sides of the spine should be balanced and working symmetrically. When this symmetrical function is not obtained, the body is forced to compensate, which results in energy consumption. The sEMG technology measures such imbalances to further analyze/identify the presence of subluxation(s).

Both static and dynamic electromyography exist under the umbrella of "surface EMG" to quantify the degree of functionality within a person's system.[22] Evidence suggests that patients with chronic low back pain have abnormal paravertebral muscle activity. Patients with this condition have increased muscle tension resulting in pain via spasm, vasoconstriction, and ischemia. These patients with chronic low back pain have different EMG results than those who are normal (without chronic pain).[23]

Furthermore, chronic low back pain sufferers may also display atrophic muscles, and alteration of muscle fibers, coordination, and proprioceptive abilities.[24] Thus, sEMG is utilized to understand the musculature and physiological changes associated with chronic pain. In the case study being described throughout this paper, the chiropractor utilized static EMG to evaluate the patient's musculature/energy usage. Refer to Figure 1 for sEMG results.

The reliability of surface EMG was shown by Limm et al. to be good-to-excellent for short and intermediate-term evaluation. This study analyzed the reliability of surface EMG during voluntary motor tasks in those with spinal cord injury. There were a total of 10 voluntary tasks performed.

Limm et al. concluded that sEMG may be useful indetermining CNS motor control when an objective and repeatable measure is necessary. The author notes that the limitations of this study include: electrode placement differences by a few millimeters to a centimeter from the original scanned site as additional scans were performed.[25] Other studies have demonstrated the reliability of paravertebral EMG for static and dynamic movements.[23,26]

Review of Chiropractic Literature

The majority of the literature surrounding ADHD and chiropractic is comprised of case studies, all of which describe a positive outcome for the patient as a result of chiropractic care.[14,27-32]

One case study presented by Bedell describes a 7-and-a-half-year-old female who was brought to the chiropractor by her mother with "subtle ADHD findings" suggested by the child's teacher. In addition to the school's findings, the mother reported focusing problems, hyperactive behavior, sleep disturbances, and negative and aggressive behaviors toward the child's sister.

The chiropractor analyzed the child using Torque Release Technique (TRT) and adjusted the patient based on this protocol in the cervical and sacral regions. It was also suggested by the chiropractor that the child consume fish oil capsules daily and consume whey protein in morning shakes in addition to chiropractic care. Following three weeks of care, the mother noted a decrease in irritability and aggressive behaviors and nervousness and an increase in listening ability, project completion, and organization skills.[27]

A 2009 case study by Stone-McCoy et al. describes a three-and-a-half-year-old male with symptomatology related to ADHD. The child had tantrums and biting issues during school. In addition to Toggle recoil adjustments of the atlas, the mother was advised to decrease the child's consumption of food additives and sugar. Omega-3 EFA supplements were also added. As a result of care, parents and teachers have reported improvement in the patient's attention and energy levels as well as improved academic grades.[14]

Another proposed mechanism for the presence and exacerbation of ADHD symptoms relates to the cervical kyphosis. Two case studies present young males, ages 4 and 5, with diagnosed ADHD.[28-29] Cassista notes that the child was extremely hyperactive and was dismissed from daycare. The child had a history of ear infections, coughing, asthma, little food consumption (decreased appetite), and disrupted sleep patterns.

A Pierce Acu-arc instrument measurement revealed a cervical spine kyphosis of -85cm. Over the course of two and a half months, the child received occiput/C1 and lower cervical adjustments using the Pettibon -Z adjusting instrument and Thompson drop protocol. At the child's reevaluation on the 13th visit, the mother stated that the child had a normal appetite and sleep patterns improved.

He had stopped coughing and was less hyperactive. The last reevaluation showed marked improvement in asthma symptoms, the quality of schoolwork the child produced, task management, and behavioral issues had dissipated. A +17cm lordosis was present on film.[28]

Similarly, a case study by Bastecki et al. showed 127% loss of normal cervical lordosis in a 5-year-old boy. Chiropractic Biophysics (CBP) was utilized over the course of 35 visits. At the 12th visit, the mother noted positive changes with decreased severity and frequency of tics. At the last visit, a 29% loss of lordosis was noted. This was a 98% improvement from the first visit.[29]

A case report by Ester presents a 9-year-old male with a history of infection, asthma, migraine headaches, and tics. By the end of care, the child had complete elimination of tics, asthma symptoms, insomnia, hyperactivity, headaches, depression and neck pain.[30]

Other case reports by Newman, Hospers et al., Peet, Darragh et al., and Muir have depicted similar success in decreased symptomatology related to ADD and ADHD as a result of chiropractic care.[14,31-33] Combined symptoms of tics,[34] bipolar disorder,[35] and sleep problems[36] along with ADHD have also improved via chiropractic care.

Two pilot studies conducted by Walton et al. and Giesen et al. with sample sizes of 13 and 7 subjects, respectively, demonstrate positive outcomes in those with learning disabilities, behavioral impairments, and other associated ADHD symptoms.[31]

Thus far, only case studies, case reports, and pilot studies have been included in this portion of the discussion.[14,27-32] A retrospective case series conducted in 2010 by Alcantara et al. included all male patients aged 7-11 years. Three inclusion criteria were established.

These include: previous medical diagnosis of ADHD, history and physical examination performed to screen for comorbidities and contraindications to spinal manipulation, and the patient had received chiropractic care for at least a 5-month period. Diversified and Gonstead adjustments were delivered to the subjects. Both individually and as a group, improvements were noted in ADHD symptoms, as well as positive behavioral, social, and emotional outcomes.[37]

Limitations

Bastecki et al. wrote a case report and included limitations regarding the outcome of that particular case. The author portrayed that chiropractic care may be unrelated to the positive outcome(s) exhibited by the patient suffering from ADHD and that one must consider spontaneous remission of ADHD symptomatology. Bastecki et al. continues by addressing the possibility that the individual may have been misdiagnosed.

A false sense of improvement must also be considered as the patient's parents may not have been reporting the retrospective symptoms accurately.[29] The author has demonstrated a unique and realistic perspective on the limitations surrounding the improvement of ADHD symptoms as a result of chiropractic care. These limitations relate to the case study described throughout this discourse. While the case study adds to the literature supporting the role of chiropractic care with ADHD patients, it is limited to one patient outcome. The child in this study was also not formally diagnosed with ADHD, as Bastecki et al. describes. Spontaneous remission must also be considered.

As depicted in the review of literature, it is presumed that various chiropractic techniques can be beneficial for those with ADHD. Diversified technique was utilized in this case study, whereas other studies include CBP, TRT, Toggle recoil, Gonstead, Pettibon, and Thompson Techniques.[14,27-29,37] Relief of ADHD symptoms utilizing various chiropractic techniques enhances the claim that chiropractic can aid those with ADHD. However, additional research in the form of randomized control trials is necessary to enrich the pre-existing literature.

Additional limitations of this study include lack of long-term outcomes as a result of care and the lack of objective outcomes. The analyzation of subluxation was done via Diversified analysis, thermography, and sEMG. These objective measures were used at each reassessment for evaluation of subluxation. ADHD outcomes were merely addressed based on the mother's subjective findings.

The Role of the Vertebral Subluxation Complex and the Effect of the Adjustment

The term "subluxation" has an extensive history of both utilization and definition. Its first definition was recorded in 1688. Since that time, Rome has listed a total of 296 variations and synonyms for the term used various professionals including chiropractors, medical doctors, and others. The latest model by Lantz incorporates nine components of the vertebral subluxation complex. These include: kinesiology, neurology, myology, connective tissue physiology, angiology, inflammatory response, anatomy, physiology, and biochemistry.

Kent has expounded upon this model to include The Dysafferentation Model, among others, which describes neurological dysfunction associated with the vertebral subluxation.[38] The intervertebral motion segment is comprised of two adjacent vertebral bodies, the facet joint, the intervertebral disc, and various soft tissue structures.39 This intervertebral motion segment has immense nociceptive and mechanoreceptive structures.

When biomechanical dysfunction is present (i.e. subluxation), there may be an alteration in the nociceptive and/or mechanoreceptive response. McLain discovered that Type I, Type II, and Type III mechanoreceptors, as well as unencapsulated nerve endings are housed within cervical facet joints. The presence of these structures within the cervical facet joints implies a central nervous system connection. Neural input from the facet joints is critical for proprioception and pain sensation within the cervical spine.

Furthermore, weight bearing discs and proper mechanoreceptor function is responsible for the regulation of postural neurologic information and muscular function. These structures influence these neurological and muscular functions via the unconscious anterior and posterior spinocerebellar tract, cerebellum, vestibular nuclei, medial and lateral vestibulospinal tracts, and regulatory anterior horn cell pathway. It can be assumed, based on this information, that

proper alignment of the cervical spine (in particular) is critical for brain input/stimuli. As stated in Kent's article, "correcting the specific vertebral subluxation cause is paramount to restoring normal afferent input to the CNS, and allowing the body to correctly perceive itself and its environment."38 Investigating the information surrounding this case study in greater detail leads the reader to understand that the child has an issue with hyperactivity and proprioception as the child feels a "constant urge to bounce and jump".

It can be postulated that abnormal cervical biomechanics can lead to such behaviors. It is interesting to note that the child's first and second cervical vertebrae were adjusted at each visit (52 total visits) and that improvement was noted as a result of these adjustments. The notion that abnormal spinal motion and positioning can lead to aberrant brain function is further explained by Brieg who stated that the mechanical and physiologic changes in the spinal cord, brainstem, and higher brain centers is proposed to be related to abnormal static postural positions.[29]

Stone-McCoy et al. offers a different, yet related theory behind the vertebral subluxation and the presence of ADHD symptoms. The Brain Reward Cascade relates neurotransmitter production within the Central Nervous System (CNS) that ultimately results in a sense of well-being. When a patient is functioning optimally (i.e. free of subluxation), a cascade of neurotransmitters within the CNS are generated and creates a sense of well-being.

In those with ADHD and other addictive and compulsive disorders, it has been stated that D2 dopamine receptors may be dysfunctional due to a defective gene. The lack of a sense of well-being leads some individuals to turn addictive substances or compulsive behaviors for momentary satisfaction. In addition to genetic factors, loss of normal neurological function, such as vertebral subluxations due to physical, emotional, and chemical traumas, as well as illness, nutritional deficiencies, and drug and medication interactions are also associated with dysfunctional Brain Reward Cascade.

Research has demonstrated that vertebral motor units are related to the Brain Reward Cascade. The nocioceptive reflex in the vertebral joints extends to the limbic system where the cascade transpires. The dorsal roots and dorsal horn is an extension of the limbic system; it is not solely housed within the brain.[14] Thus, misalignments of the vertebra (particularly cervical spine) can alter the Brain Reward Cascade, aiding adequate neurotransmitter release and function, altering behavior, and improving ADHD symptomatology.

Conclusion

This case represents a child who entered the chiropractic clinic alongside his mother with the chief complaints of behavioral issues, and a constant urge to bounce and jump. In addition to the current complaints, the child had a history of ear infections and abnormal neurological development as the child skipped crawling before walking and currently exhibits toe walking. Thermography and sEMG studies demonstrated a dysfunctional nervous system that was attributed to vertebral subluxation. The chiropractor identified areas of subluxation based on Diversified Technique. The patient did not receive immediate relief, but symptomatology improved over the course of care.

While this case study adds evidence to the claim that chiropractic care can improve symptoms associated with ADHD and related conditions, it does not solidify this claim. Additional research in the form of clinical trials and RCTs would greatly enhance the current literature surrounding this issue.

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Appendix

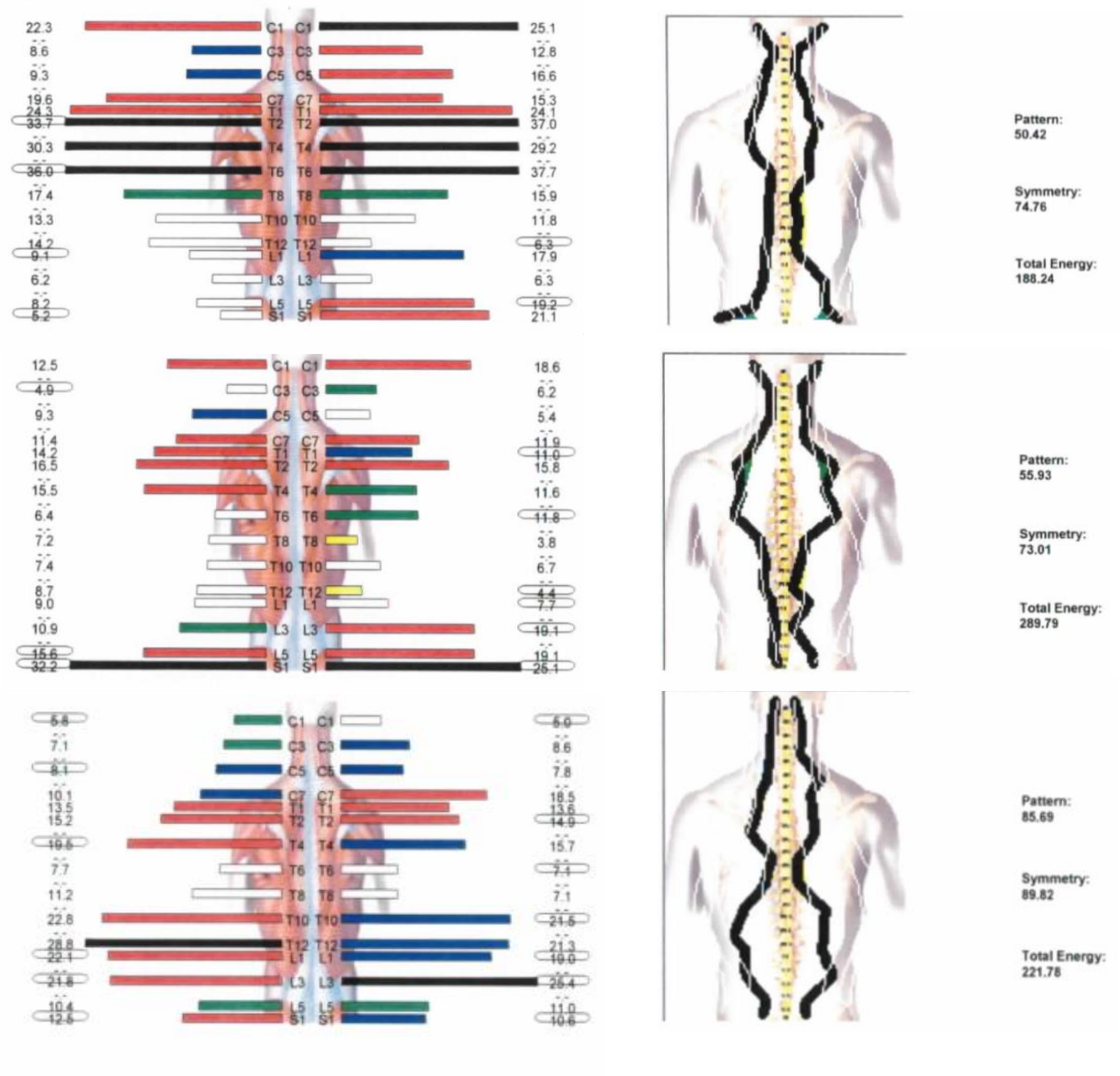

Figure 1. The patient was scanned using the CLA Insight Millennium Model at the initial visit and each reassessment. The initial visit is represented by the top images. The left scan is the amplitude scan and the right is the pattern view. The amplitude scan measures tension of the paraspinal activity. Green bars are mild elevation (compared to normal), blue bars are moderate elevation, and red bars are high elevation. White bars are normal. The pattern view specifies how energy is distributed within the spine. Pattern, symmetry, and total energy is listed.[22]

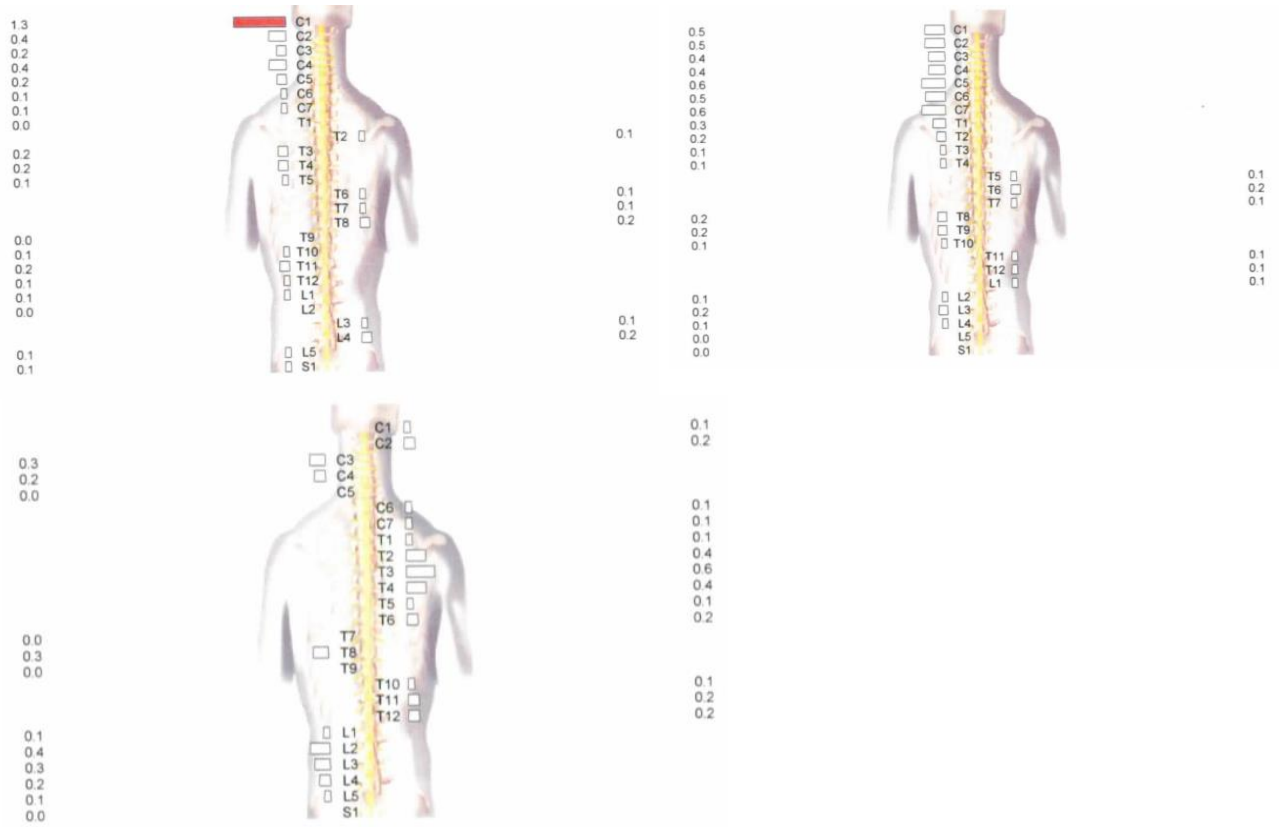

Figure 2. The patient was also scanned using the 2nd generation Insight Rolling Thermal Scanner at the initial visit and subsequent reassessments. This scanner is used to evaluate autonomic nerve function via temperature readings. Improvement is noted throughout the course of care.[36]