CASE STUDY

Improvement in Alpha Brain Waves, Coordination and Emotional Regulation in a Pediatric Patient with Chiropractic Care Using Network Spinal Analysis

Matthew Mancuso, DC[1] & Janet Cheng, DC[2]

Abstract

Objective: The objective of this report is to describe improvements in Alpha Brain Waves, coordination and emotional regulation experienced by a patient undergoing subluxation-based chiropractic care using Network Spinal Analysis.

Clinical Features: A 7-year-old female presented with slow physical skill acquisition and difficulty with coordination since birth. She had an aversion to using utensils, preferring to use her fingers to self-feed. She also had emotional outbursts and low self-esteem of two years duration.

Intervention & Outcomes: Management of this case is based on Reorganizational Healing (ROH) including chiropractic care through Network Spinal Analysis (NSA) for the reduction of facilitation within the spinal cord. The promotion of structural correction of the misalignment component of the associated vertebral subluxation and Somato Respiratory Integration (SRI) to connect enhanced somatic awareness with respiration were also goals of care. After two months there was improved Alpha Waves, coordination, spontaneous use of silverware for self-feeding and an improvement in emotional regulation.

Conclusion: Further research is warranted to examine the effect of chiropractic on brain waves and the development of coordination and emotional regulation in the pediatric population.

Key Words: *chiropractic, vertebral subluxation, adjustment, coordination, emotional regulation, Network Spinal Analysis (NSA), Alpha Brain Waves*

Introduction

Chiropractic is a health care discipline that serves to optimize health through the principle that the body has an innate intelligence by which it sustains and maintains itself. Chiropractors place particular emphasis on the subluxation, which compromises neural integrity and can cause deleterious effects to health.[1] In recent years, the association between the correction of vertebral subluxation and quality of health has been studied in greater detail with objective measures showing what chiropractors have long been reporting anecdotally.[2-3] Chiropractic care and the correction of vertebral subluxation have been associated with cases relating to improvements in quality of life,[4] structural integrity,[5] attention[6] and development of language,[7] among other aspects of health and wellness.[2-3]

The concept of subluxation is understood through various component models and categorizations of clinical applications as presented by Kent. Tonal approaches tend to view the spine and the nervous system as a functional unit with particular interest on functional outcomes, which are of value in subluxation-centered research.[8] Network Spinal Analysis is

1. Private Practice of Chiropractic, Worthington, OH
2. Private Practice of Chiropractic, Athens, GA

one such tonal approach, and it is a low-force spinal application within the Reorganizational Healing paradigm that is widely used by chiropractors.

The purpose of Network Spinal Analysis is to improve the cognitive and precognitive awareness of an individual's passive spinal structures, active tension patterns, and development of unique standing waves of skeletal motor activity believed to assist in improved self-organization of the spine and nervous system.[3] Network Spinal Analysis utilizes a system of assessment and intervention for the development of emerging organizational properties in the spine and nervous system to improve spinal and neural integrity, adaptability, and to advance wellness and quality of life.[9] The Network Phasing System is used to identify and prioritize the category of subluxation, and the spinal segment(s) to be adjusted.[10] NSA recognizes two categories of subluxation arising from Panjabi's subsystem model.[11] Structural subluxation is thought to be initiated by physical trauma or mechanical stress, resulting in misalignment and consequent nerve interference. Facilitated subluxation is thought to occur as an effect of spinal cord tension and nerve root pressure, causing osseous misalignment as a result. Facilitation is an aberrant sensory and motor response to the accumulation of sub-threshold stimuli over time, which leads to a loss of spinal integrity.[10]

The application of a low force touch contact following NSA protocol often generates oscillatory movements of the spine synchronized with deep respiration[10] which serve two purposes: to reduce facilitation within the spinal cord while promoting the structural correction of the misalignment component of the associated vertebral subluxation.[10] Clinical outcomes specific to the initial level of NSA care include awareness and entrainment of respiratory motion with spinal motion, reduction of parameters of adverse spinal cord tension, release of tension from spinal stability subsystems, enhancement of spinal and neural integrity, reorganization of spinal structures, development of body's ability to self-regulate tension, and an increase in basic somatic awareness.[9]

It is proposed that a reduction of sympathetic state coupled with an increase in awareness of respiration, energy and movement allows the frontal lobe and vagal centers to more readily assess perception, structure and behavior.[3] One study by Miller found that subjects receiving Network care have a significant decrease in electrodermal activity, an indirect measure of the sympathetic nervous system, compared to control subjects.[12] The biological mechanism by which these changes are promoted is yet to be understood and would benefit from improved outcome measures of cortical activity concomitant with chiropractic care.

The literature describing tonal chiropractic approaches and changes in pediatric behavior is limited. Children most frequently present for wellness care,[13] followed by condition-based care for respiratory, digestive, sleep and musculoskeletal complaints.[13-15] To date, there have been a few studies on chiropractic care in the pediatric population on safety and effectiveness.[13-14] While individuals under Network care tend to report improvements in wellness and positive changes towards health lifestyle practices in adults,[2-3] few studies report the effect on children.

The purpose of this case study is to document the parent-rated improvements in coordination and emotional regulation reported in association with in a 7-year-old female under Network Spinal Analysis care.

Case Report

History

A 7-year-old female presented with her mother for chiropractic care. According to the mother, she had slow physical skill acquisition and difficulty with coordination since birth. She ate with her hands and avoided the use of utensils. She had emotional outbursts and low self-esteem of two years duration. The mother reported that emotional outbursts were drawn out, sometimes lasting from hours to days.

The mother reported that the gestational period was 40 weeks and five days in duration. Ultrasound was utilized at seven weeks for pregnancy confirmation, at 20 weeks to monitor growth, at 23 weeks for gender identification (3D ultrasound) and at 40 weeks prior to birth. A fetal non-stress test was performed at 40 weeks, indicating low activity of the fetus. Labor was induced due to low amniotic fluid and the mother was administered a spinal epidural. The mother had a vaginal (cephalic) birth at a hospital with an obstetrician present. Total duration of labor was 10 hours, including two hours of active labor. Infant was born with no evidence of birth trauma. APGAR score was 9/10 at birth and 10/10 at five minutes. At birth, infant received silver nitrate eye drops, a vitamin K injection, and a Hepatitis B vaccination. The mother experienced post-partum depression with no difficulties breast-feeding or bonding. The child was breastfed for 11 months, after which cow's milk was introduced following the cessation of breast-feeding. At age two, a vaccination series including MMR was administered. The child experienced adverse reactions to vaccinations including fever, malaise, transient hives, irritability, and drowsiness. She developed a respiratory infection shortly post-vaccination for which she received two courses of antibiotics. The child was never introduced to formula and has no known food intolerances or allergies. The child slept well, 8-10 hours a night regularly. The child has no night terrors, sleep-walking or difficulty sleeping.

The mother reported that child's developmental milestones are as follows: responded to sound at one month, followed an object at two months, held head up at four months, sat alone at seven months, crawled at nine months and began walking at one year of age. The mother reports the child as having behavioral problems and emotional outbursts. The child has attended daycare in a home setting since age two. At the time of the writing she is currently 7-years-old and is homeschooled using a computer-based program. She spends over 15 hours a week at the computer, and approximately 24 hours a week at play. Child does not engage in any sports. She does not wear glasses or contact lenses and does not have trouble reading. There is no history of hospitalizations or surgeries. Child eats a healthful diet consisting of organic foods, raw vegetables, beef, poultry, whole grains and fruit supplemented with a daily multi-vitamin. She drinks water regularly.

Chiropractic Assessment

Analysis and adjustment procedures utilized in the management of this case are based on Network Spinal Analysis (NSA), developed by Donald Epstein, DC. An initial examination was performed to assess the presence of Adverse Mechanical Cord Tension (AMCT) including vertebral subluxation and spinal defense patterns using NSA protocol. Spinal and neural integrity was assessed through motion and static palpation, neurological assessment and an evaluation of stress response consisting of electroencephalography, heart rate, skin conductance, temperature, respiratory rate, and surface electromyography.

Motion palpation revealed moderate to severe decrease in intersegmental motion indicating passive subsystem tension at left C1, right C3, T3, T7, T8, right L5 and coccyx spinal segments. Static muscle palpation revealed significantly taut fibers in the cervical spine and at the right sacroiliac area associated with active subsystem tension. On a scale of 1-5, with 5 being the most severe, tension is rated as a 4/5 overall. Tension within the neural control subsystem was present as indicated by heel tension, eversion stress and abduction stress. Significant heel tension, defined as resistance to dorsiflexion from full plantarflexion, was found corresponding to coccyx AMCT and was rated as severe (5/5). Eversion stress, or resistance to eversion from inversion, was moderate to severe (4/5) and is considered demonstrative of lateral cord tension. Abduction stress, as revealed by an increase of resistance to hip abduction, was mild to moderate (2/5). Adduction stress was subclinical (0/5). With patient prone and legs in the extended position, patient has a ½ inch left functional short leg. Head rotation resulted in a fast lengthening of the short leg, characteristic of C1 AMCT associated with a cervical vertebral subluxation.[10]

Examination included a Stress Response Evaluation using electroencephalogram (EEG), heart rate variability, heart rate, skin conductance, temperature, respiration rate and paraspinal surface electromyography (utilizing Neuroinfiniti). The Stress Response Evaluation records two baseline readings with eyes open and eyes closed, three challenges (i.e., cognitive – math/stroop test, emotional – noise stress, and physical – breathing exercise) alternated with three recovery periods. The purpose of this evaluation is to determine the state of activity and engagement at baseline, adaptation under stress, and recovery to baseline when stressors are removed. Setup for the exam includes placement of a respiration belt around the patient's diaphragm, placing temperature, galvanic skin response (GVR) and blood volume pulse (BVP) sensors at the fingertips, sEMG pads at the mastoid, and EEG contacts on ears and scalp.[16] The results are as follows:

- **EEG** is a test of cortical activity using electrodes attached to the ears and scalp to measure brain wave frequencies. Stress events including the math test, noise and breathing exercise typically increase beta activity while increased alpha and theta waves are seen during relaxation and recovery. The stress response test demonstrated good beta engagement indicating good focus, good theta engagement indicating good subconscious relaxation, fair alpha engagement indicating fair conscious relaxation and poor sensorimotor rhythm engagement indicating poor central nervous system reorganization. EEG analysis demonstrated that the alpha wave production was below the ideal 22%, indicating a decreased ability for conscious relaxation. It was noted that the neurological pattern response is under-aroused, indicating a state of too little beta wave activity or too much alpha, theta, or delta.

- **Heart rate variability** is used to measure stress effects, but it was inaccurate in this case due to age and the related increased heart and respiration rates.

- **Heart rate** is a measure of pulse at baseline, under stress, and at recovery using BVP sensors at the fingertips. Heart rate was within normative average for her age at 100-103. Heart rate was increased at baseline reading with eyes closed and there was an inverse response to noise.

- **Skin conductance** is a test of the neurological response to stress and recovery to baseline as measured in the amount of moisture produced by the sweat glands in the hands detected by GSR sensors at the fingertips. It is a measure of a person's ability to reduce the effects of the stressor after the event. The child demonstrated poor recovery after the noise stress challenge and the breathing challenge, high response to the math/stroop challenge and noise challenged, with an increased rate during the breathing challenge.

- **Temperature** was within normal limits at baseline and under stress. The normal response to stress is constriction of blood from the extremities with a reduction of temperature in the extremities.

- **Respiration rate** was measured using a respiration belt around the diaphragm. Child is within normative range for her age at 12-20 respirations per minute. Respiration increased during recovery and decreased during stress events. It is noted that child held her breath during the math test, and had increased rate during the breathing exercise. Breathing rate remained the same at rest and at exercise.

- **Surface EMG** is a test of motor activity in a relaxed state and in active motion, measured with sEMG pads at the mastoid. sEMG analysis demonstrated high muscle tension, high stress response and a high tension response to math test. Child is an upper respiratory breather.

Chiropractic Care

The patient's care plan consisted of two spinal entrainments a week for eight weeks accompanied by weekly Somato Respiratory Integration sessions and a progress examination at the conclusion of eight weeks. At each visit, she was assessed

using NSA protocol for indicators of subluxations associated with adverse mechanical spinal cord tension and secondary vertebral subluxations. Specific force applications were utilized based on the above parameters. NSA level of care response was graded according to progression of the Respiratory Wave. Somato Respiratory Integration exercises were facilitated weekly in office for Stages 1 and 2 to increase awareness of the body and of its different rhythms.

Network Spinal Analysis is an application of spinal Reorganizational Healing that is currently practiced by chiropractors. It involves low force contacts to the spine, accessing unique "spinal gateways" in applications termed spinal entrainments to enhance the self-regulation of passive, active, and neural spinal subsystem tension, somatic awareness, and neural coherence. It is accompanied by SRI to create conscious awareness and integration with the body as a tool to "experience life with increasing depths of internal connection and wider ranges of human expression."[9] Network Spinal Analysis and Somato Respiratory Integration (SRI) are elements of Reorganizational Healing (ROH), the overarching paradigm that promotes progressively complex strategies in the baseline function of a system for growth[17] and draws on self-assessment and utilization of resources to promote sustainable change.[9] NSA and SRI are utilized together in this case for the patient's care.

There are five phases in the Network Spinal Analysis protocol, each correlating with specific osseous structures and parameters indicating AMCT. Parameters assessed in NSA include palpation, leg length, heel tension, eversion stress, adduction stress, abduction stress, cervical syndrome and flexion leg check (patient is prone with legs extended, from which knees are passively flexed). These parameters assist the practitioner to determine which phase, and therefore what osseous level to affect.[10] Defense physiology associated with adverse mechanical cord tension is assessed through palpation of the stabilizing spinal subsystems as described by Panjabi.[11] Once the phase is determined, the practitioner then determines the specific location of a "spinal gateway" on the osseous level and a contact is made here with a low force contact to affect an adjustment.[10]

Somato Respiratory Integration utilizes specific exercises that connect enhanced somatic awareness with respiration. These exercises are associated with self-generated dynamic processes to dissipate energy stored as tension, enhance structural flexibility, increase the experience of safety within the body, and demonstrate characteristic shifts in states of consciousness. SRI exercises are facilitated by a practitioner in the office and can be used by the patient at any time as a strategy to focus attention and increase awareness. In this case, Stages 1 and 2 were facilitated to increase somatic awareness and bringing awareness to the body's different rhythms. For the Stage 1 exercise, patient brings awareness to sternum, xiphoid, and umbilical areas and determines the position of most ease and the position with least ease. She then breathes into the area of most ease for 2-3 breathes with a nose-mouth breath and into the area of least ease for 1-2 breaths. This is repeated, alternating with specific statements of acknowledgement relevant to stage 1. In Stage 2, patient breathes into the area of most ease and alternates with the area of least ease until a rhythm is developed. As with stage 1, there are specific statements of acknowledgement relevant to stage 2.[18]

Changes in Behavior and Overall Health

After the first spinal entrainment, the mother reported that the child spontaneously started using silverware, which she previously avoided due to difficulty with coordination. After eight weeks of care, she continues to be able to use silverware during self-feeding. The mother reports that her child is better able to regulate her emotions, specifically when it comes to "changes in plans and doing things she may not want to do." She states that her emotional discharge is complete, instead of being drawn out over days. There also seems to be a deeper understanding in why things need to be done, i.e. homeschool, bathing, etc. She has improved coordination, decreased aversions to tasks requiring coordination (including self-feeding using silverware), and she now is able to play with a soccer ball.

A progress evaluation was performed to assess for progress in the correction and optimization of structural or facilitated spinal subluxation patterns associated with Adverse Mechanical Cord Tension (AMCT). The observed response to care improved from a Level 1AB at the first spinal entrainment to a Level 1C/2A, indicating that a contact made at the sacrum elicited a smooth, muscular movement synchronized with increased respiration at the entire length of the spine. This level of response coupled with a reduction in spinal facilitation suggests progression towards synergy of vertebrae and associated musculature, which is generally accompanied by early signs of improvements in quality of life.[10]

Motion palpation revealed moderate decrease in intersegmental motion indicating passive subsystem (vertebrae, disc, and ligaments) tension at right C1, left C2, left C3, right C6, right T4, T5, T11, right T12, right L4 and left sacrum spinal segments. Static muscle palpation revealed mild hypertonicity in the upper thoracic, left lumbar and right sacroiliac areas. On a scale of 1-5, with 5 being the most severe, tension is rated at a 1/5 overall. Neural control subsystem (spinal cord, nerves and meningeal dura) tension was present as indicated by moderate to severe heel tension (4/5), mild eversion stress (1/5), subclinical adduction stress (0/5), and moderate to severe abduction stress (4/5). With patient prone and legs in extended position, patient has a right functional short leg less than ¼ inch.

A Stress Response Evaluation (Neuroinfiniti) was conducted at the conclusion of 8 weeks to include electroencephalogram (EEG), heart rate variability, heart rate, skin conductance, temperature, respiration rate and paraspinal surface electromyography. The stress response analysis demonstrated improved alpha responses at baseline, with noise, and during the breathing exercise as well as improved SMR responses with a shift from an inverse response (engagement during stress) towards a healthy response of engagement during recovery. EEG analysis demonstrated improved SMR responses and improved alpha responses with an increase in alpha power in hindbrain and frontal cortex.

Heart rate variability was not utilized due to inaccuracies

relating to age and associated increase of heart rate and respiration rate. Heart rate analysis demonstrated improved heart rate at baseline, indicating decreased anxiety. Skin conductance analysis showed improved skin conductance during recovery from noise and emotional stressors. Temperature analysis indicated a sympathetic response to stress as indicated by coldness of hands. Respiration rate demonstrated an improvement in breathing control and improved respiration responses at baseline. Data from surface EMG analysis was unusable due to poor contact during evaluation.

Discussion

Chiropractic care in this case study was presented from a subluxation-based perspective and a Reorganizational Healing paradigm, which emphasizes the development of strategies for self-sustaining growth towards health and wellness. The outcome measures utilized reflect an enhanced ability of the body to self-regulate tension and the development of improved cognitive and precognitive awareness to more readily assess perception, structure, and behavior.

Central Pattern Generator

The respiratory wave phenomenon, also known as the Network wave, is best described as a Central Pattern Generator, an interconnection of neurons that produces movement of the limbs and trunk that can be sustained in the absence of direct sensory input or higher cerebral involvement. Previous to 2004, Central Pattern Generators have generally been described in its relation to locomotion, including walking, running, swimming, and flying. This was the first time that a CPG has been observed within the spine apart from locomotion or respiration.[19]

The Network wave is a coherent movement elicited by this Central Pattern Generator. A light pressure contact to the spinal gateway is sufficient to elicit an oscillation which rapidly becomes self-sustaining without further sensory input from the practitioner. A contact made at the sacrum elicits an electrophysiological wave that initially dissipates before reaching the cervical spine and after some entrainment eventually reaches the cervical area and triggers oscillation of the neck at a specific vertebral level.[20] The development of the Network wave is believed to be associated with the correction of vertebral subluxation as well as reduction of facilitation within the spine.[10]

Decreased adverse mechanical cord tension is a necessary precursor of the Network wave.[19] sEMG signals recorded at the cervical, thoracic, lumbar and sacral areas demonstrate synchronization of movement and coherence of the wave throughout the spine.[20] Additionally, the respiratory wave exhibits mathematical properties of a central pattern generator. At advanced levels of NSA care, sEMG signals became less random and move towards higher levels of organization with more coherence and predictability. The dynamic movements produced following a contact progress towards increased complexity.[19]

EEG Alpha Activity

EEG is used to measure oscillatory activity of the cortex. Of particular interest is the alpha frequency band (8-12Hz), which has been linked to cognitive performance and creativity.[21] EEG alpha oscillations appear to play a role in cognitive, sensorimotor, psychoemotional and physiological aspects of human life[22] while theta oscillations are intimately related with the cognitive component of the emotional response.[23] Alpha wave activity can also been measured as individual alpha peak frequency, which is the dominant oscillatory frequency in the human EEG during relaxed wakefulness.[24] A variety of EEG rhythmical components are described by the same dominant frequency as the alpha rhythm, with distinct frequency and topographical boundaries.[22]

Individual alpha peak frequency varies intra-individually as a function of age, increasing from childhood until puberty and then decreasing after 40 years.[22] Increases in iAPF are not linear, but occur in several growth spurts.[25] In children, iAPF has been found to have a significant correlation with measures of sensorimotor performance and locomotor skill.[26] This corresponds to a period of increased iAPF between 1 and 3 years of age from 5.5Hz to 8Hz, at which children rapidly develop locomotion and coordination.[25]

Studies have demonstrated an increase in alpha activity during cognitively demanding tasks as well as an increase in frontal activation during creative ideation.[21,27] During a cued-attention tactile detection task, alpha and beta rhythms exhibit phase synchrony from the suppression of stimulus processes and motor response to stimulus.[28] The Neural Efficiency hypothesis is such that these inhibitory processes facilitate cognitive performance while supporting working memory processes.[22] Alpha activity, particularly in the frontal cortex, may reflect high-demand internal processing and top-down inhibitory processes through inhibition of task-irrelevant information.[21]

Children's brain function should shift from theta dominance to alpha dominance by school age, demonstrating an increase in cognitive efficiency and allowing greater capacity to learn, think, and be consciously relaxed. Seeing this increase at CZ (the frontal cortex) is an indicator of this process happening, and correlates with the anecdotal findings reported by the child's mother.

Conclusion

This case reported the improvement in coordination and spontaneous utilization of silverware while self-feeding as well as improvement in emotional regulation following a 2-month period of subluxation-based chiropractic care using Network Spinal Analysis. These changes coincide with an increase in alpha activity as measured in EEG, which suggest an increase in cognitive efficiency allowing greater capacity to learn, think, and be consciously relaxed. These changes are temporally associated to chiropractic care and the correction of vertebral subluxations.

This study provides limited evidence that Network Spinal Analysis care may be safe and effective in improving coordination and emotional regulation. Further research is

warranted to determine the effect of chiropractic care on pediatric behavior, wellness and quality of life. Investigations of the physiological mechanisms by which these changes occur are important topics for future study.

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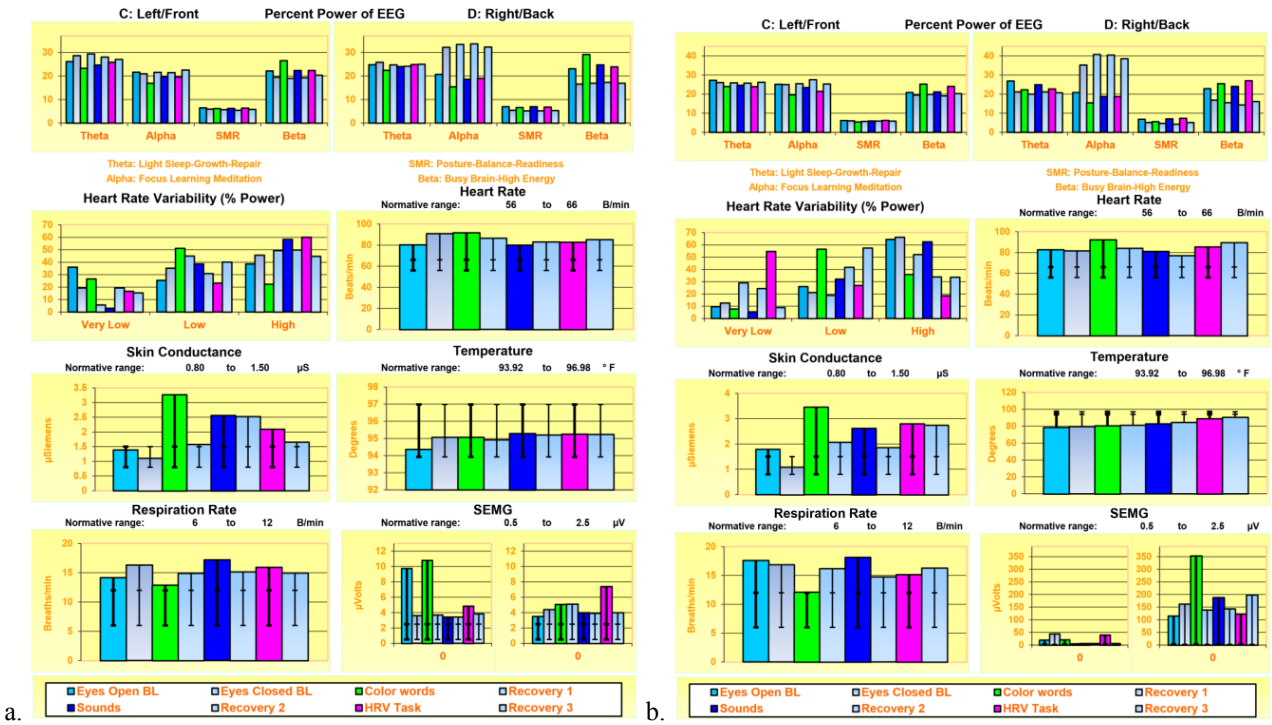
Appendix

	Initial Examination	**Progress Examination** (8 weeks)
Motion Palpation: decrease in intersegmental motion	(4/5) Moderate to severe at left C1, right C3, T3, T7, T8, right L5 and coccyx spinal segments	(3/5) Moderate at right C1, left C2, left C3, right C6, right T4, T5, T11, right T12
Static Palpation: tension in active subsystem	(4/5) Significantly taut fibers in the cervical spine and at the right sacroiliac area	(1/5) Mild hypertonicity in the upper thoracic, left lumbar and right sacroiliac areas
Heel Tension: resistance to dorsiflexion from full plantarflexion	(5/5) Severe, corresponding to coccyx AMCT	(4/5) Moderate to severe
Eversion Stress: resistance to eversion from inversion	(4/5) Moderate to severe	(1/5) Mild
Abduction Stress: resistance to hip abduction	(2/5) Mild to moderate	(4/5) Moderate to severe
Leg Length Inequality	½ inch left	< ¼ inch right

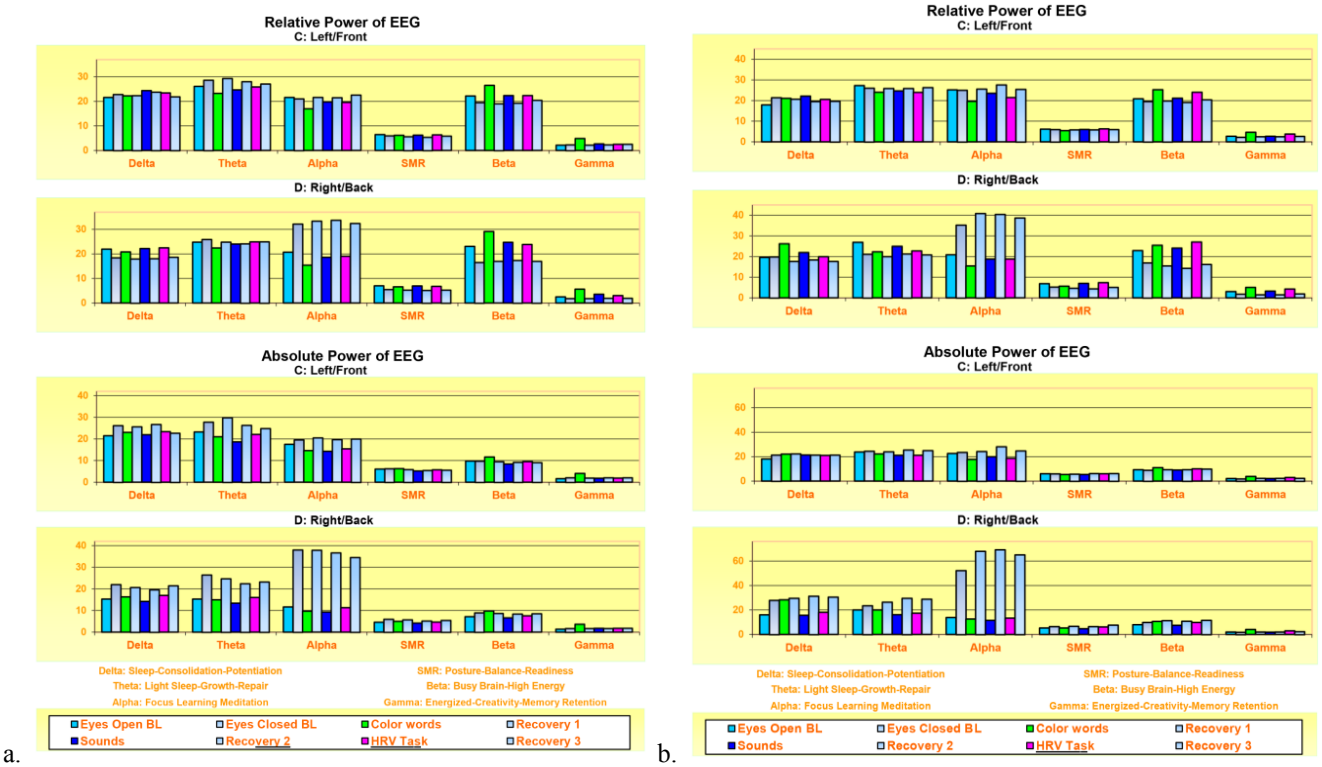
Table 1. Chiropractic Examination Findings

Examination findings, demonstrating increase in intersegmental motion, decrease in hypertonicity, decrease in heel tension, eversion stress, increase in abduction stress and decrease in leg length inequality based on a scale of 1-5, with 5 being severe.



a. b.

Figure 1. Stress Response Evaluation
Comparison of Electroencephalogram (EEG), Heart Rate Variability (HRV), Skin Conductance, Temperature, Respiration Rate, Surface Electromyography (a) at initial exam and (b) at progress exam.



a. b.

Figure 2. Relative and Absolute Electroencephalogram (EEG)
Comparison of Relative and Absolute Electroencephalogram (EEG) (a) at initial exam and (b) at progress exam.