Improvement in Pattern Analysis, Heart Rate Variability & Symptoms Following Upper Cervical Chiropractic Care

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ABSTRACT

Objective: This paper reports thermal pattern analysis and heart rate variability outcome on three cases undergoing an upper cervical chiropractic technique.

Clinical Features: Three patients who had never received upper cervical chiropractic care were examined both pre and post adjustment using the Tytron C-4000 paraspinal digital infrared instrument and the BioSuite HRV to assess autonomic nervous system function via heart rate variability.

Interventions and Outcomes: Cervical radiographs, paraspinal digital infrared imaging, and pelvic balance leg length inequality were used to confirm upper cervical subluxation. Analysis was applied to determine pre-adjustment cervical thermographic pattern. A heart rate variability test was also preformed pre-adjustment. A Knee Chest Upper Cervical Specific adjustment was administered to the C1 region of the spine in all three cases. The three patients were then instructed to lie in a supine position for 45 minutes. The patients were then re-tested for pelvic balance leg length, re-scanned with the Tyron C-4000 instrument, and post tested with the HRV unit. Subjective findings improved following care as well as a concomitant reduction in pattern and improvement in heart rate variability findings.

Conclusion: In these three cases there appears to be a relationship between the improvements in bilateral skin temperature pattern analysis and heart rate variability following an upper cervical chiropractic technique. It is feasible that upper cervical chiropractic care can have a positive effect on the autonomic nerve system and there may be a connection between pattern reduction and improved heart rate variability. Further study is recommended.

Key Terms: chiropractic, pattern analysis, heart rate variability, upper cervical, vertebral subluxation, thermography, knee chest adjustment.

Introduction

The heart rate variability (HRV) examination was selected as a diagnostic tool to evaluate physiological significance of pattern reduction following the application of an upper cervical chiropractic technique.
There have been multiple studies demonstrating autonomic nervous system health and balance improvements through chiropractic care. In this study we have observed a relationship between changes in HRV examination, pattern analysis and subjective symptoms.

Degeneration of the spine due to vertebral subluxation has been described as a progressive process associated with abnormal spinal mechanics. The degenerative changes are concomitant with various mechanisms of autonomic neurological dysfunction. These degenerative processes have been shown to disturb the somatic nerves as well as both the sympathetic and parasympathetic portions of the ANS. Damage to the autonomic nervous system, or autonomic neuropathy, has been shown to lead to conditions such as heart disease, diabetes, syncope, vertigo, tachycardia, and migraine-type headaches. ANS analysis using heart rate variability has also been shown to identify pre-diabetic conditions as well as predict the chances of development of diabetic neuropathy.

The heart rate variability (HRV) examination is becoming more commonplace in the chiropractic clinic. It is a natural fit for the chiropractor wanting to evaluate the function of the autonomic nervous system (ANS). The HRV examination accomplishes various important dimensions in assessing ANS health. It readily measures the overall activity of the ANS, a direct measure of ANS health and adaptability. HRV also measures activity of the sympathetic and parasympathetic branches of the ANS, balance between the sympathetic and parasympathetic branches of the ANS, activity of the hypothalamus and its role as ANS coordinator and the neuroendocrine relationship of the ANS to the adrenal system.

In this study, measurement and analysis of HRV data was performed by the BioSuite HRV™ biosignal analysis unit designed by HRV Enterprises LLC. The BioSuite HRV is designed to assess the Autonomic Nervous System (ANS) using Heart Rate Variability (HRV), Electrocardiography (ECG) and Galvanic Skin Response (GSR). Its software algorithms are based on the standards of the Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology. Its reliability in education and research has been published in peer-reviewed scientific journals. The computer software has been designed and tested at one of the world’s leading medical research universities.

The BioSuite HRV uses four different measurements to assess ANS function: The ANS activity index, ANS balance ratio, ANS categorization, and Fourier transform. The ANS activity index was selected as the primary HRV assessment tool in this study due to its use of simple time domain analysis. The ANS activity index gives an overall assessment of the autonomic nervous system and yields raw statistics which lend easily for comparison purposes. Autonomic activity index is based on the standard deviation of the R to R intervals known as SDRR calculation.

The autonomic activity index is then expressed as a score on a composite scale (in milliseconds) made up of several different studies of normal SDNN values. The scale runs from 0 to 150 with 0 being no ANS activity and 150 being the upper limit of normal in adults. The higher scores represent a healthier functioning autonomic nervous system. Scores of 80 or below represent an ANS activity index below optimal with progressively lower scores indicating poorer autonomic health.

**Pattern Analysis**

Pattern analysis (PA) has been an important component in the practice of various upper cervical chiropractic techniques for over 80 years. Skin temperature is regulated by the autonomic nervous system. Examination of skin temperature generally gives us an avenue of assessing autonomic function. Various studies have supported the connection between pattern analysis and autonomic function.

There has been an evolution in analysis with Dr. BJ Palmer being the original author and investigator. Beginning in the 1950’s Dr. Stephen A. Duff further refined pattern analysis. Other investigators have worked on various computer aided models to quantify thermographic findings. These methods have added value to the understanding of paraspinal thermography as well as establishing a more solid footing in the area of intra and inter-examiner reliability for the Tytron infrared instrument.

In this study, the Tytron C-4000 infrared digital paraspinal thermographic instrument was used. The Knee Chest Upper Cervical Specific (KCUCS) protocol for pattern analysis has been adopted from the Stephen A Duff system of pattern analysis.

The Duff Analysis does not lend itself readily to the computer aided models offered in previous studies. The computer aided model using the thermal pattern calculator is a sophisticated mathematical analysis that views the paraspinal thermographs globally whereas the Duff Analysis identifies specific points within each graph to establish points referred to as constants.

The cervical reading is initiated at the T1 spinous process. Each bilateral probe is placed on its corresponding side of the cervical spinous processes adjacent to the T1 spinous process. The scanner gun is rolled up the neck to just below the external occipital protuberance (see figure 1). The specific point of origin for the scan is noted and recorded by the examiner for the purpose of accurately repeating subsequent scans with same length and same measuring field. The Tytron software allows the examiner to observe the scan length during the examination. This permits an accurate scan length which is essential to this type analysis. Each scan should not vary over 1 mm in length. To determine the patient’s specific pattern the examiner will perform 5 pre-adjustment readings on at least 2 separate time frames 30 minutes or more apart.

The ultimate goal of the paraspinal thermograph is a straight line from an inferior perpendicular line to a superior perpendicular line. A break reading is defined as any portion of the graph that deviates to the left or right of the straight line at any given point. The scans are analyzed for the purpose of detecting consistencies with break readings. This is done either by a marking program adopted onto the Tytron software as seen in figure 2 or manually with a ruler.

Pattern Analysis & HRV
A perpendicular parallel line is drawn through the base of any given break reading seen on at least 4 of the 5 graphs. Break readings that reproduce themselves in the exact position, from superior to inferior, on at least 4 of the 5 initial paraspinal thermographic readings are labeled “constants”. Break readings that do not reproduce themselves in the exact position of at least 4 of the 5 initial patient readings are labeled “variables”.

Variables are discounted from future analysis. The top constant is constant 1 and each subsequent constant will be labeled in numerical order going from superior to inferior on the graph. The superior constant seen at the top of the graph is considered the most important and is called the “Pattern Angle” (PA). A patient’s pattern is made up of these constants and is unique. A majority of the established constants within the patient’s pattern will return consistently when a patient is not adapting optimally from a neurophysiological perspective. This has been associated clinically with the upper cervical subluxation.

Once the constants have been identified the best representation out of these 5 initial graphs is selected for future comparison and analysis. The example pattern graph is selected on the criteria of having all the constants and the best representation of the top constant or pattern angle (PA) (see figure 2).

The pattern analysis assessment scale (PAAS) has been developed by the authors as a method of quantifying the above described “constants” with each individual patient’s pattern. Utilizing the PAAS progress either toward pattern or away from pattern can be determined as well as measuring percentage of progress or regression in the patient’s status. The PAAS gives the highest weight to the PA followed by a lesser value for the 2nd constant. Constants 3-5 have an equal value that is less than constant 2. All constants after 5 are accessed an equal value which is less than constants 3-5.

There are 4 possible straight forward assessments to be made in regards to each individually established constant. The constants will either be present (P), present reduced (PR), opposite pull (OP) or clear (C). Present is defined as the break reading present with the same of very similar intensity to the example pattern. Present reduced represents a break reading that is consistent with the example pattern with reduced intensity. Opposite pull is a break reading that breaks in the opposite direction from the established break on example pattern. In this case the example pattern may have a left break at the constant 4 position. In the case of OP, the break would be to the right at the constant 4 position. A clear reading is given when no break is seen at the established constant point. The highest score belongs to P, PR has a lesser value, OP an even lesser value and C is tabulated as zero. See Table 1 for a PAAS scoring guide.

3 consecutive patients were selected with criteria of having an ANS activity index below 80 and 21 years of age or older. Pattern analysis was performed as a part of KCUCS protocol on each of the cases before and after their initial upper cervical chiropractic adjustment. The paraspinal thermographs were scored on the PAAS and a percentage of pattern reduction was determined. In addition, an HRV examination was performed prior to the first adjustment and another one following the administration of the upper cervical chiropractic adjustment. The PAAS scores and HRV results were compared.

Case Series

Case 1

Patient History

A 35 year old 5’9” 226 pound male truck driver presented with right shoulder and neck pain that radiates into the right arm and forearm. He experiences episodes of numbness and tingling in his right hand. Symptoms first began 10 years prior to admission and have progressively worsened over the past 1 year. On the 1 to 10 pain scale the patient reports hovering around 6 most of the time over the past 6 months. In addition the patient reported occasional dizziness, pain between the shoulders, heart burn and frequent colds. He also stated that he is not currently taking any medications.

Examination

Blood pressure, pulse, and pulse oximetry were all measured and within normal limits. The initial examination as well included a cervical and right shoulder regional exam, abdominal examination, paraspinal digital infrared imaging, pelvic balance assessment, and cervical spine radiographs.

The neck and right shoulder pain was a 7 on the 1 to 10 pain scale. Upon physical examination it was discovered the patient had a restriction of right head rotation and right head tilt with pain. Upon neck extension the patient experienced numbness and tingling in the right forearm and hand.

Maximal foramina compression was positive on the right with pain radiating into the right shoulder. Lymph node swelling was detected in the left cervical chain with tenderness. Trigger points were noted in the right trapezius and right rhomboid muscles. Patient experienced pain upon palpation of the right axillary region. All shoulder range of motion and orthopedic exams were within normal limits. The abdominal examination revealed tenderness in the upper right and lower right quadrants. All other findings including auscultation were within normal limits.

A skin temperature differential analysis (STDA) was performed on the full spine and cervical spine via Tytron C-3000 infrared instrument. Pattern analysis was employed to determine constants within the cervical spine graph. The patient’s pattern was determined to have 7 constants.

A pelvic balance leg length inequality (LLI) examination was performed in the prone position and revealed an 8 mm short right leg. Pelvic balance LLI has been commonly used as an assessment toll in various upper cervical chiropractic techniques for a number of years.25,26

Cervical radiographs were ordered due to presenting symptoms, positive cervical spine STDA examination, and the physical examination. Three cervical views were obtained; APOM full cervical in stereo and a neutral lateral cervical. The stereo x-ray analysis is performed with a dual view box with mirrored prisms and gives the examiner a 3 dimensional
view. For the purposes of the APOM, the stereo x-rays give a representation of head position as it relates to the cervical spine as well as the position of the upper cervical vertebrae.

The APOM demonstrated a slight right head tilt with a rotatory curvature convex left. The 1st cervical vertebra is right lateral relative to its corresponding condyle and the 2nd cervical vertebra has a right body rotation with a spinous process deviated left of midline. The spinous process of C3 and lower are in the midline. The neutral lateral demonstrates an anterior weight bearing with a slight cervical curve reversal apex C3/C4 motor segment. Moderate fanning is noted at the C3/C4 interspinous space and slight fanning is noted at C4/C5. The atlas lateral angle is 9 degrees and the C2 body is anterior and superior relative to the C3 superior facets.

A primary upper cervical listing of atlas anterior superior right (ASR) was selected. This represents the atlas misaligning anterior and lateral the right condyle. The superior component of the misalignment is a positional analysis of the atlas anterior tubercle in the misaligned position. The secondary listing of axis anterior left superior (ALS) is derived from the left inferior facet of C2 shifting anterior and superior relative to the left superior C3 facet. Left depicts the position of the C2 spinous process relative to the midline.

A heart rate variability examination was performed using the BioSuite HRV™. HRV analysis for any subject focused on overall ANS activity as measured by the ANS Activity Index®. The pre-adjustment HRV scan demonstrated an ANS Activity Index score of 56.90 indicating a low amount of variability in the patient’s nervous system.

Interventions and Outcomes

A chiropractic adjustment was administered to the atlas with the primary listing of ASR. The Knee Chest Upper Cervical Specific (KCUCS) technique was employed for the purpose of correcting the C1 subluxation. The KCUCS upper cervical adjustment has been detailed in the literature.²⁸,²⁹

The patient described feeling much improved after the C1 adjustment. His pain level went from 7 on the 1 to 10 pain scale to 2. STDA and HRV examinations were performed within one hour of the initial KCUCS upper cervical adjustment.

The Duff method of pattern analysis using the authors PAAS scoring system showed a 60.00% reduction of the original pre-adjustment pattern. Post pattern analysis exhibits opposite pattern angle with 3 of 7 original constants returning. The pattern angle showed an “opposite pull” demonstrating intellectual adaptation. Constant 3, 6 and 7 returned reduced in nature, with constant 6 showing complete return.

The HRV post scan demonstrated an ANS Activity Index score of 88.50 indicating an amount of variability in the patient’s nervous system that was within normal limits. This represents a 59.31% improvement in the patients ANS activity, and overall ANS health. See figure 3 for pre/post HRV findings and pattern analysis scoring.

Case 2:

Patient History

A 67 year old 5' 4", 182 pound female presented complaining of high blood pressure. She reported being diagnosed with hypertension one year prior to her visit in the clinic. The patient was not taking any medications at the time of her visit. She had taken hypertensive medication beginning one year previous but had self-discontinued 6 months ago. The patient stated medication was not effective in her case. She also reported episodes of rapid heartbeat and occasional heal pain. The patient reported having a total hysterectomy 6 years previous. She reports incontinence as well as experiencing afternoon fatigue.

Examination

Upon initial evaluation the patient’s blood pressure was measured at 156/100 in the left arm with lower extremity blood pressure measured in left ankle 144/92. Her pulse rate 94, pulse oximetry 95%. General observation showed bilateral ankle edema, vertical rigged fingernails, and myxedema. Ophthalmic examination revealed silver lining of central artery right eye and left was not visualized. All other EENT findings were within normal limits. Cervical spine examination revealed decreased range of motion in left and right rotation, left and right lateral bending all without pain.

A skin temperature differential analysis (STDA) was performed and analyzed as with Case #1 and found to have 5 constants.

A pelvic balance leg length inequality (LLI) examination was performed in the prone position and revealed a 10 mm short left leg. Cervical radiographs were ordered due to presenting symptoms, positive cervical spine STDA examination, and the physical examination. The same radiographic examination was performed as with case #1. The APOM demonstrated a slight right head tilt with a right tower presentation of the cervical spine. The 1st cervical vertebra is left lateral relative to its corresponding condyle and the 2nd cervical vertebra has a right body rotation with a spinous process deviated left of midline. The spinous process of C3 and lower are in the midline. The neutral lateral demonstrates a slight anterior weight bearing with moderate degeneration in the lower cervical spine. Fanning is present at the C4/C5 motor segment. The atlas lateral angle is 24 degrees and the C2 body is posterior relative to the C3 superior facets.

A primary upper cervical listing of atlas anterior superior left (ASL) was selected. This represents the atlas misaligning anterior and lateral the left condyle.

The pre-adjustment HRV scan demonstrated an ANS Activity Index score of 29.90 indicating a very low amount of variability in the patient’s nervous system.

Interventions and Outcomes

A chiropractic adjustment was administered to the atlas with the primary listing of ASL using the KCUCS technique as described previous. Following the adjustments and the
protocols established for the KCUCS another heart rate variability examination was performed as well as blood pressure measurement and paraspinal skin temperature thermography.

The patients post blood pressure was measured at 134/96 in the left arm. The PAAS score showed a 15.00% reduction of the originally established pattern. The post reading exhibited a reduced pattern tendency with all five original constants returning in varied degrees. Specifically there were readings of reduced constants at constant 2, 3 and 4 and constant 5 showed complete return of reading.

The post HRV ANS Activity Index score was 36.70 indicating an amount of variability in the patient’s nervous system that was still low but improved from the pre-adjustment scan. The patient experienced an 18.5% improvement. See figure 4 for pre/post HRV findings and pattern analysis scoring.

Case 3:

Patient History

A 42 year old 5’ ½” 114 pound female presented with constant pain from between the shoulders down to the hips. Patient reports the pain to be an 8 on the 1 to 10 pain scale. She reports fatigue, loss of sleep, nervousness, difficult digestion and constipation. The patient told the examiners her pain began 2 years previous after lifting a heavy box. She has taken omeprazole for GERD for 2 years and had ovarian cysts removed 7 years previous.

Examination

Blood pressure was measured in her left arm at 88/63, pulse 83, and pulse ox 99%. Upon general inspection the patient appeared to be in pain. Pain and tenderness was found in the mid thoracic and L5/S1 regions upon palpation. All ranges of motion in the lower back were within normal limits. Cervical spine range of motion showed a decreased right lateral bending and right rotation. Posture examination demonstrated a right head tilt, right high shoulder and the right ileum high. Abdominal examination discovered significant pain upon palpation in the lower left quadrant and upper right quadrant. Bowel sounds were diminished upon auscultation.

A skin temperature differential analysis (STDA) was performed on the full spine and cervical spine via Tytron C-3000 infrared instrument using the same protocol of performance and analysis as described in the previous cases. Through the process of pattern analysis the patient was determined to have 5 constants. A pelvic balance leg length inequality (LLI) examination was performed in the prone position and revealed a 10 mm short right leg.

Cervical radiographs were ordered due to the positive cervical spine STD analysis and the physical examination. Three cervical views were obtained using the same protocol of performance and analysis as described in the previous cases. The APOM demonstrated a slight right head tilt with a rotatory curvature apex left. The 1st cervical vertebra is left lateral relative to its corresponding condyle and the 2nd cervical vertebra has a right body rotation with a spinous process deviated left of midline.

The neutral lateral demonstrates a straight cervical curve. The atlas lateral angle is 12 degrees. The primary upper cervical listing selected for this patient is atlas anterior superior left (ASL). This represents the right lateral mass of atlas shifting anterior relative to its corresponding condyle with the C1 anterior tubercle superior and the entire atlas misaligned laterally to the left.

The pre-adjustment HRV scan demonstrated an ANS Activity Index score of 54.80 indicating a moderate amount of variability in the patient’s nervous system.

Interventions and Outcomes

A chiropractic adjustment was administered to the atlas with the primary listing of ASL. The KCUCS technique was employed for the purpose of correcting the C1 subluxation. The patient described feeling much improved after the C1 adjustment. Her pain level went from 8 on the 1 to 10 pain scale to a 4. STDA and HRV examinations were performed within one hour of the initial KCUCS upper cervical adjustment.

The PAAS score showed a 21.00% reduction of the originally established pattern. Post pattern analysis exhibited reduced pattern angle with 4 out of 5 original constants returning and constant 4 as an opposite pull.

The post-adjustment HRV ANS Activity Index score was 62.60 indicating an amount of variability in the patient’s nervous system that was still lower than optimum but 13% improved from the pre-adjustment scan. See figure 5 for pre/post HRV findings and pattern analysis scoring.

Discussion

Heart Rate Variability (HRV) is a term that describes the changes in timing between heart beats. Changes in beat intervals are measured in milliseconds or 1/1000th of a second, and it is this timing change or rate change (variability) that gives us the term Heart Rate Variability. HRV is commonly performed by measuring the time between each “R” wave (interval) in the ECG recording. Sophisticated mathematical calculations are then applied to this list of numbers, and the information derived from these calculations is then used to measure and analyze all of the factors that were previously mentioned. It is also important to note that pulse rate does not equal heart rate, and that what is being measured in HRV are the electrical impulses from the ventricles, and not blood flow pulsing through the arteries.

Heart rate variability is often measured by two methods: Time domain analysis, which produces raw statistics, and Frequency domain analysis that presents information in graphical form. In this study we have focused on the Time domain analysis. Time domain analysis involves simple numbers that correlate to specific parts of the Autonomic Nervous System. Application of the simple statistical calculation yields a single number. This single number is used to describe three things about the ANS.
Those are: overall activity of the ANS, overall health of the ANS, and adaptability of the ANS. This value is of principle concern because it reflects both the sympathetic and parasympathetic effect on the heart, as well as all of the other cyclical components involved in heart rate variability. It therefore represents a broad overall marker of ANS activity and is the starting point for HRV interpretation.

**Pattern Analysis & HRV Correlation:**

Improvements were noted in both HRV activity index scores as well as pattern reduction in all three cases following the application of an upper cervical chiropractic technique. Of particular interest for this case report, case 1 demonstrated the most significant HRV outcome while having the greatest amount of pattern reduction as calculated by the PAAS. Cases 2 & 3 both experienced more modest improvements in HRV and modest improvements in pattern reduction. A relationship has been established with this small sample between improvements in autonomic activity index and reduction of pattern (see figure 6).

**Conclusion**

HRV improvements have been reported following chiropractic care which is consistent with our findings. In this paper three cases were graded on pattern reduction using the PAAS score following upper cervical chiropractic care and compared to the HRV outcomes. Subjective findings, PAAS scores and HRV analysis all demonstrated improvement. It appears that the upper cervical chiropractic care in these cases had a positive effect on HRV and the level of improvement was consistent with the level of pattern reduction.

Pattern reduction has been observed clinically by upper cervical doctors relating to positive improvements in physiology. However, the literature remains sparse linking pattern reduction with objectively measured positive physiological outcomes. This is a small sampling of patients and does not carry the necessary weight to be considered conclusive. Much more study is needed in this area. It is the hope of the authors that this report will encourage other investigators.

**References**

10. HRV Parser Software 2.3 for windows written by Chris Wellstood, Qubit Systems Queen's University at Kingston, Ontario, Canada.

Figures and Tables

Figure 1a: Doctor preparing for paraspinal thermographic examination; Figure 2b: The letter “A” represents the start position for the examination; Figure 2c: The letter “B” represents the end point of the examination just below the external occipital protuberance.

Figure 2: Illustration of how to mark pattern
Figure 3: Case 1 pre/post Pattern Analysis and HRV readings
Figure 4: Case 2 pre/post Pattern Analysis and HRV readings
Figure 5: Case 3 pre/post Pattern Analysis and HRV readings
Figure 6. Bar Graph relating HRV activity index and Pattern Reduction

Table 1

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<tr>
<th>Constant Labels</th>
<th>Points scored</th>
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<td></td>
<td>CC</td>
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<tr>
<td>CC  Constant Clear</td>
<td>0</td>
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<tr>
<td>CP  Constant Present</td>
<td>0</td>
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<tr>
<td>CR  Constant Reduced</td>
<td>0</td>
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<td>OP  Opposite Pull</td>
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