THE EFFECTS OF A CHIROPRACTIC UPPER CERVICAL ADJUSTMENT ON THE AUTONOMIC NERVOUS SYSTEM AND CARDIOVASCULAR SYSTEM USING AN ELECTROCARDIOGRAM

A dissertation submitted to the Faculty of Health Sciences,
University of Johannesburg, in partial fulfilment of the requirement for the degree
of Masters of Technology Chiropractic:

By

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DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Masters Degree Chiropractic at the University of Johannesburg. It has not been submitted before for any degree or examination in any other tertiary education institution.

____

Lynelle van Tonder

This __________day of ____________ 2009.

AFFIDAVIT: MASTER'S AND DOCTORAL STUDENTS

TO WHOM IT MAY CONCERN

This serves to confirm that I, **Lynelle van Tonder**, ID nr: **7611120052086**, student nr **802045088** enrolled student for the qualification **MTech Chiropractic** faculty Health Sciences herewith declare that my academic work is in line with the Plagiarism Policy of the University of Johannesburg. I further declare that the work presented in the dissertation is authentic and original, and that there is no copyright infringement in the work. I declare that no unethical research practices were used or material gained through dishonesty. I understand that plagiarism is a serious offence.

Signed at _____________________ on this __________day of _________ 2009.

_____________________________   ___________________

Signature   **Print name**

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Affidavit certified by a Commissioner of Oaths

DEDICATION

To my husband and son Gert, my parents and sister.

"we dance around in a circle and suppose,
but in the middle sits the secret and knows"

Robert Frost

ACKNOWLEDGEMENTS

Appreciation must be extended to the parties without whom this study would not have occurred.

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ABSTRACT

This study was conducted to determine whether Chiropractic Spinal Adjustment Therapy (SAT) of the upper cervical spine has an effect on the normal physiological reactions that take place in the Autonomic Nervous System and Cardiovascular System whilst using the Electrocardiogram as a monitoring device. This area within Chiropractic research calls for further studies to be conducted.

One hundred and twenty normotensive participants between the ages of 18 and 30 years were recruited to partake in the study via an advertisement placed in and around the University of Johannesburg Doornfontein Campus (Appendix A). Participants were assessed for exclusion criteria by completing a Full Case History (Appendix B), Pertinent Physical Examination (Appendix C), Cervical Spine Regional Examination (Appendix D) and a S.O.A.P. note (Appendix E). Participants were excluded from the study if it was revealed that they have contra-indications to Chiropractic SAT (Appendix F).

The participants demonstrating upper cervical spine dysfunction were treated with a Chiropractic upper cervical SAT (Appendix J) while they were monitored for 3 minutes before, during treatment and 3 minutes after treatment by means of the Electrocardiogram to monitor the cardiovascular response. Participants were asked to read and sign the Subject Information and Consent form (Appendix G). Participants were required to complete the Patient Biographical Information Sheet (Appendix H) and the Patient Questionnaire regarding treatment experience (Appendix I)

An analysis was performed using Repeated Measures Analysis, Cross Tabulation, t-Test, Frequencies, Descriptives and Friedman's Tests.

The results of this study showed that Chiropractic SAT of the upper cervical spine had an effect on the Autonomic Nervous System and Cardiovascular System thus causing an average decrease of 2.03 beats per minute in the Mean Heart Rate.

Possible explanations for this decrease is firstly the stimulation of the Superior Cervical Cardiac Branch of Vagus Nerve (House, E. L., Pansky, B. and Siegel, A., 1979), secondly the stimulation of the Cervicosympathetic Reflex (Knutson, G., 2001) or moderation of muscle tone and thirdly the elimination of the effects of the Pressor Reflex (Knutson, G., 1998).

The results of this study however, also showed that Chiropractic SAT of the upper Cervical spine had no statistically significant effect on Heart Rhythm, P-Wave or QRS-Complex.

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CHAPTER ONE –INTRODUCTION

1.1 Introduction

In 1996, the Association of Chiropractic Colleges (ACC) published the following statement in a consensus document regarding the role of the subluxation in the Chiropractic paradigm: Chiropractic is concerned with the preservation and restoration of health, and focuses particular attention on the subluxation. They further stated that a subluxation is a complex of functional and/or pathological articular changes that compromise neural integrity and may influence organ system function and general health (Masarsky and Todres-Masarsky, 2001).

Numerous studies regarding this topic have since followed and will be discussed in detail in Chapter Two. Chiropractic treatment has become well known to have an effect on the visceral organs of the human body including the heart as studied by Budgell and Hirano (2000). It is of vital importance that the Chiropractic research scope therefore even further expand to include topics such as the effect of Chiropractic spinal adjustive treatment (SAT) on the cardiovascular system (CVS) and autonomic nervous system (ANS) because of these systems' involvement in major diseases.

Heart disease ranks as the number one killer in developed countries of the world and will soon be the main killer on all the continents. The most commonly applied technique in the investigation of cardiology matters is Electrocardiography (ECG) (Rowlands, 1980). By intensifying research on the ANS and CVS, opportunities will be created for other Chiropractic researchers to further investigate the possibility of Chiropractic intervention in the treatment of heart disease.

Driscoll and Hall (2000) recommended further development of a reliable and reproducible experimental protocol before validating the effects of SAT on the ANS and CVS. They also recommended further research on the effect of spinal adjustment on the ANS and CVS using ECG as monitoring device (Driscoll and Hall, 2000).

1.2 Aim of the Study

Following the recommendations by Driscoll and Hall (2000), the aim of this study was to determine the effect of Chiropractic treatment, in particular SAT of the upper cervical spine, on the normal physiological reactions that take place in the ANS and CVS whilst using the Electrocardiogram (ECG) as a monitoring device.

Objective measurements that were taken included: heart rate, heart rhythm, P-interval and QRS-complex.

1.3 Possible Outcomes

The possible outcomes for this study would be adding to research on the influence of Chiropractic SAT on the ANS and CVS. To reveal the effects, if any, of Chiropractic SAT on heart rate, heart rhythm, P-interval and QRS-complex.

CHAPTER TWO – LITERATURE REVIEW

2.1 Nerve Innervation of the Heart

The heart receives both Sympathetic and Parasympathetic input from the ANS. The Sympathetic Nervous system (SNS)'s main function is to prepare the body for an emergency. In the heart, Sympathetic stimulation increases contraction rate, force and cardiac output. The Parasympathetic System is orientated towards energy conservation and restoration (Snell, S., 1997). In the heart, Parasympathetic (Vagal) stimulation decreases heart rate, contraction force and cardiac output (House, *et al*., 1979).

2.1.1 Sympathetic nerve supply to the heart

Figure 2.1 demonstrates how pre-ganglionic sympathetic supply to the heart arises from the lateral gray horn of the spinal cord segments first to fifth thoracic vertebral level (T1 – T5). The fibres synapse in all three cervical and in the uppermost five thoracic ganglia of the sympathetic chain. Post-ganglionic adrenergic fibres are distributed to the specialised myocardial cells of nodal and conducting tissues, to the general myocardium and to the coronary arteries (Moore and Dalley, 2006).

2.1.2 Parasympathetic nerve supply to the heart

The pre-ganglionic parasympathetic supply arises in the dorsal nucleus of the Vagus nerve. The fibres synapse within mural ganglia on the posterior walls of the atria and in the atrioventricular groove as indicated in Figure 2.1. Post-ganglionic cholinergic fibres supply the same tissues as those of the sympathetic chain although the direct supply to the ventricles and coronary arteries is minimal. There is however, interaction between sympathetic and parasympathetic nerve supply (Moore and Dalley, 2006).

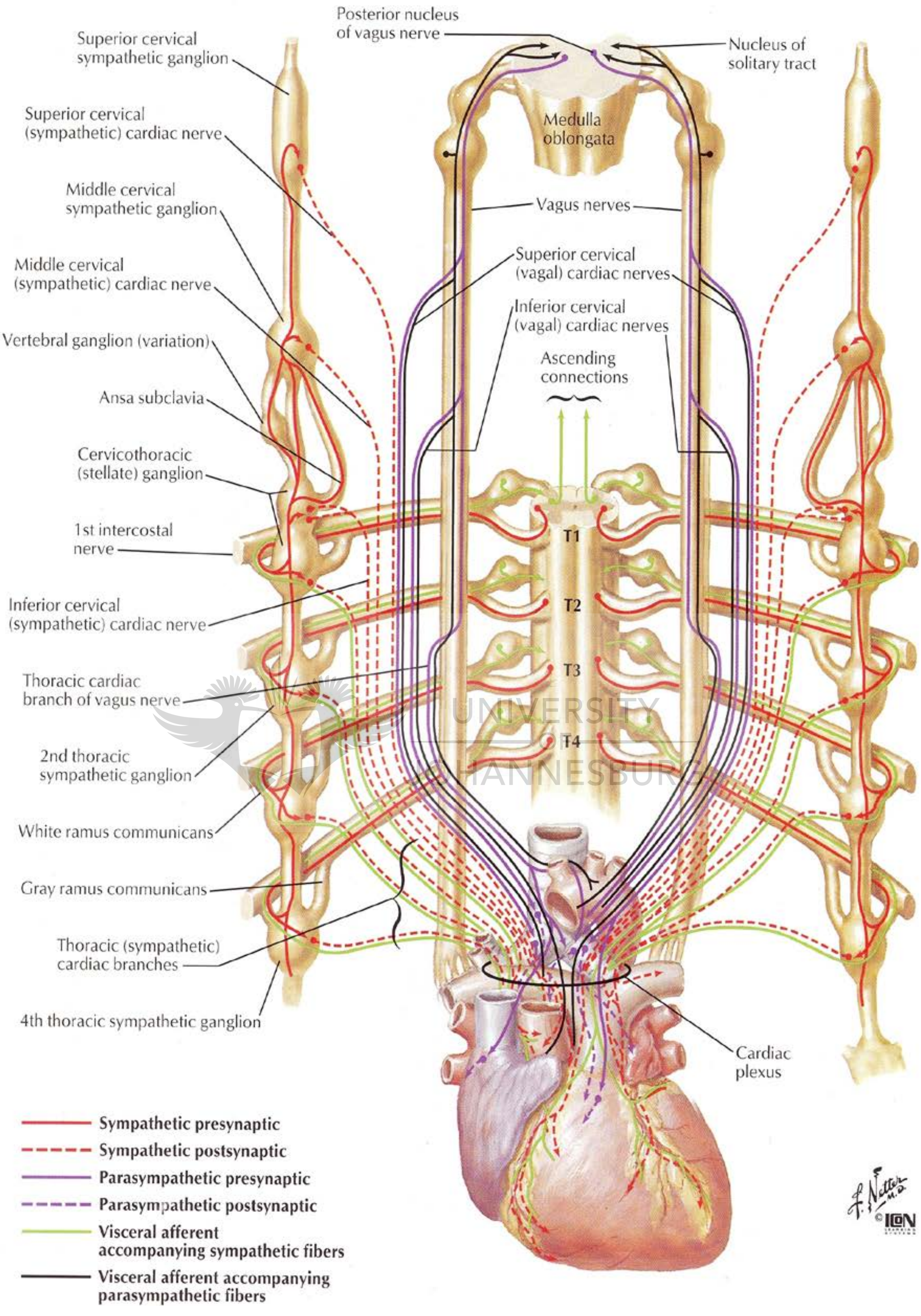

Posterior nucleus
of vagus nerve
Nucleus of
solitary tract
Superior cervical
sympathetic ganglion
Medulla
oblongata
Superior cervical
(sympathetic) cardiac nerve
Middle cervical
sympathetic ganglion
Vagus nerves
Superior cervical
(vagal) cardiac nerves
Middle cervical
(sympathetic) cardiac nerve
Inferior cervical
(vagal) cardiac nerves
Vertebral ganglion (variation)
Ascending
connections
Ansa subclavia
Cervicothoracic
(stellate) ganglion
T1
1st intercostal
nerve
T2
Inferior cervical
(sympathetic) cardiac nerve
T3
Thoracic cardiac
branch of vagus nerve
T4
2nd thoracic
sympathetic ganglion
White ramus communicans
Gray ramus communicans
Thoracic (sympathetic)
cardiac branches
4th thoracic sympathetic ganglion
Cardiac
plexus
Sympathetic presynaptic
Sympathetic postsynaptic
Parasympathetic presynaptic
Parasympathetic postsynaptic
Visceral afferent
accompanying sympathetic fibers
Visceral afferent accompanying
parasympathetic fibers

Figure 2.1: Autonomic Nervous System Distribution to the Heart (Netter, 2003)

Vagus nerve

The Vagus nerve is the main parasympathetic nerve and its territory includes heart, lungs and some of the alimentary tract. The rootlets of the Vagus and Cranial Accessory nerves are in series with the Glossopharyngeal nerve and the three nerves travel together into the jugular foramen. At this point, the Cranial Accessory nerve shares a dural sheath with the Spinal Accessory nerve but there is no exchange of fibres. Just below the Jugular Foramen, the Cranial Accessory nerve is incorporated into the Vagus nerve (House *et al.*, 1979).

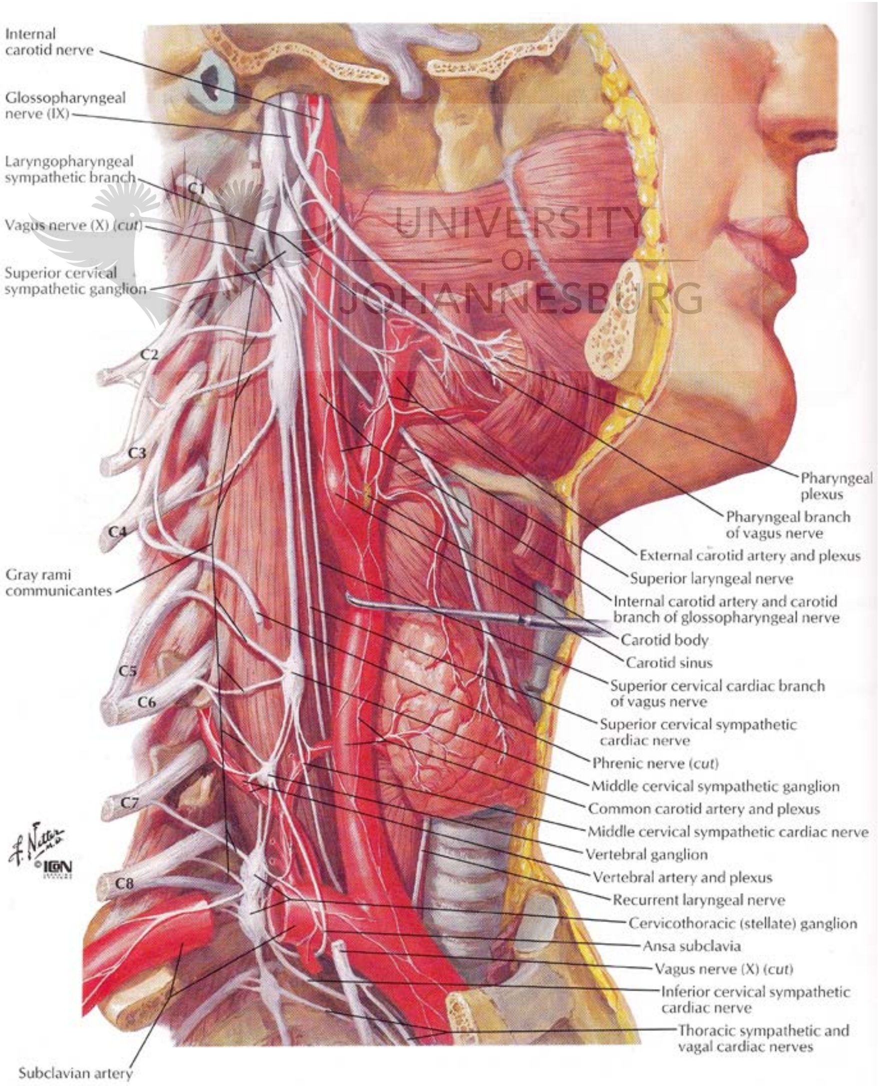


Figure 2.2: Nervous System Distribution in the Neck (Netter, 2003)

The Vagus nerve itself shows a small jugular (superior) and large nodose (inferior) ganglion which are both sensory. The parasympathetic neurons for the heart originate from the dorsal nucleus of the Vagus nerve. General visceral afferents from the heart have their cell bodies in the nodose ganglion and synapse centrally in the commissural nucleus (House *et al.*, 1979).

2.2 Anatomical Relations to the Cervical Spine and Thoracic Spine

The sympathetic nervous system shows the greatest anatomical relation to the cervical and thoracic spines. Sympathetic outflow from the spinal cord originates from the lateral horns of first thoracic to second lumbar vertebral level (T1 to L2). Fibres destined for the head, neck, body wall and limbs travel from the paravertebral ganglia via grey rami communicantes to the adjacent spinal nerves of all levels (Moore and Dalley, 2006). The paravertebral sympathetic ganglia lie in close approximation to the posterior-lateral aspects of the vertebral bodies of T1 to L2 (Netter, 2003).

Figure 2.2 illustrates how the paravertebral sympathetic chain extends above the level of T1 and includes the cervicothoracic or stellate ganglion at the level of C7/T1, the middle cervical sympathetic ganglion at the level of C5/C6 and the superior cervical sympathetic ganglion at the level of C1/C2. Communicating branches between these mentioned ganglions and the cervical spinal nerves exist at each level (Netter, 2003). The cell bodies of all the postsynaptic sympathetic fibres destined for the head region are located in the superior cervical ganglion.

From there, the fibres pass via the cephalic arterial ramus to form the carotid periarterial plexus, following the branches of the carotid arteries to their destination (Moore and Dalley, 2006). This periarterial plexus also supplies sympathetic roots to the cilliary ganglion of Cranial Nerve III , Occulomotor Nerve (Netter, 2003).

2.3 Cervicosympathetic Reflex

The somatosensory system of the neck signals nociception as well as influences motor control of the neck, eyes, limbs, respiratory muscles and the activity of some pre-ganglionic sympathetic nerves via neck-evoked reflexes. These reflexes originate in the muscle spindles from deep intervertebral muscles, golgi tendon organs and afferent nerves from Zygapophyseal joints in the upper cervical region and project to Lamina 1 and 2 of the superficial dorsal horn to terminate in higher centres like the Cuneate nuclei in the medulla, the Vagal and Hypoglossal nuclei and the Trigeminal nucleus. They also send afferent information to the thalamus and cerebellum (Bolton, Kerman, Woodring and Yates, 1998).

Research done by Bolton and Ray (1998) found evidence that the vestibular system influences the sympathetic and respiratory nerves. They hypothesised that the vestibulosympathetic reflexes set off orthostatic hypotension in positional changes by raising the blood pressure and increasing heart rate. The cervicosympathetic reflexes counter the effect of the vestibulosympathetic reflexes by decreasing the blood pressure and lowering heart rate.

Knutson (2001) found results that indicate significant decrease in systolic blood pressure in participants during palpation and vectored atlas adjustment in comparison to resting subjects. The study proposed that the drop in systolic blood pressure was due to stimulation of the cervicosympathetic reflex or moderation of muscle tone and elimination of the effects of the pressor reflex. The lack of randomisation, blinding, and a control group were factors that weakened the findings.

2.4 Pressor Reflex

The Pressor Reflex is initiated with muscle contraction. Muscle contraction causes compression of intramuscular arteries while increasing the muscle’s demands for oxygen, nutrients and waste removal. In order to overcome vessel patency restrictions, the neurological reflexes responsible for increase in systemic blood pressure are engaged (Simons and Mense, 1998).

Electromyography outcomes showed a reduction in muscle activity after adjustment of a joint dysfunction which is closely linked to abnormal muscle hypertonicity (Thabe, 1986). The upper cervical spine is associated with postural muscle control and is suggested to be signaled by actions of densely packed unique muscle spindles (Karlberg, Persson and Magnusson, 1995). Studies have shown that correction of upper cervical joint dysfunction causes immediate reduction or elimination of the postural distortion (Knutson, 1998).

2.5 The Anatomy of the Cervical Zygapophyseal Joints

The Zygapophyseal joint (Z-joint or facet joint) is defined by Gatterman (1990) as the junction between the superior and inferior articular facets of the articular process (zygapophyses) on one side of the two adjacent vertebrae.

A unique feature in the innervation of the cervical spine, in comparison with the thoracic and lumbar spines, is combined spinal nerve and autonomic contribution (Mulligan, 1957). The structures in the cervical spine, including the Z-joints, dura mater and Posterior Longitudinal Ligaments, are partially innervated by sensory nerves which travel along the sympathetic pathways. These functional links between peripheral sensory nerves and sympathetic fibres could hypothetically suggest that afferent sensory impulses from the Z-joints could affect blood vessel diameter, connective tissue metabolism and affect sensory activity within the facet joints (Johnson, 2004).

The Z-joint is supplied by the medial branch of the dorsal primary rami providing somatic sensory innervation (Gardner and Mosby, 2000). The atlanto-occipital and lateral atlanto-axial joints are instead innervated by the C1/C2 ventral rami (Groen and Stolker, 2000).

Various studies have shown that neuropeptide levels in the dorsal root ganglion cell bodies of the sensory nerves are influenced by the physiological state of the Z-joints (Johnson, 2004). Manual therapy, which includes Chiropractic SAT, directed to the Z-joints possibly affects the SNS, causing changes in autonomic activity and possible pain relief. This is apparently due to the inhibitory influences of the SNS on the spinal cord, causing adjustment-induced paraesthesia (Wright, 1995).

2.6 Chiropractic Spinal Adjustment Effects on Autonomic Nervous System

Chiropractic adjustment, as is defined by Gatterman (1990), is a manual procedure that involves a directed thrust to move a joint past the physiological range of motion without exceeding the anatomical limit. She further defines the Chiropractic adjustment as any Chiropractic therapeutic procedure that uses controlled force, leverage, direction, amplitude and velocity directed at specific joints or anatomical regions, and that Chiropractors commonly use such procedures to influence joints and neurophysiological function of the joints (Gatterman, 1990).

In order to obtain normal range of motion it is vital for any joint to exhibit joint play, which is defined as a short range of movement of a joint, independent of voluntary muscle action. Joint play is an essential factor for normal and healthy joint function and if joint play is lost, dysfunction and consequently pain will result. The Chiropractic adjustment restores abnormal joint play, thereby normalizing the joint movement and ultimately decreasing pain (Schafer and Faye, 1989).

Chiropractic SAT also serves to correct so-called “Chiropractic subluxations” or “joint restrictions”. The concept of the Chiropractic subluxation differs from the medical concept of subluxation. The medical subluxation refers to a joint instability. Chiropractic subluxation, on the other hand, is a dynamic lesion rather than an anatomical lesion which can be thought of as a joint dysfunction that activates nerve receptors in the joint capsule and surrounding tissues (Chapman-Smith, 1997). The Chiropractic subluxation is also a complex biomechanical entity with multiple factors which includes abnormal joint motion, neurological, muscular, connective tissue, vascular, inflammatory and biochemical changes. Neurological changes may induce symptoms at both a local or segmentally innervated anatomical level as well as levels distant from the site of the dysfunction (Redwood, 1997).

Spinal Adjustive Therapy aimed at such subluxations stimulates receptors in the spinal and paraspinal tissues. This stimulation activates neural reflex centres within the spinal cord and higher areas. This activation leads to somatovisceral reflexes in the ANS and somatosomato reflexes to the peripheral tissues (Haldeman, 1992). Neuroscience research supports the concept that stimulation of spinal and/or paraspinal structures may lead to ANS reflex responses that may alter visceral function (Budgell and Hirano, 2000).

2.7 The Electrocardiogram

The ECG has been shown to be of clinical use in measuring physiological changes in the CVS and has been used in Chiropractic research. The ECG has further been found to be the preferred tool to study the CVS instead of arterial tonometry equipment as it allows for a more accurate and detailed study of potential changes to the ANS and CVS (Budgell and Hirano, 2000; Driscoll and DiCicco, 2000; Knutson, 2001).

Driscoll and Hall (2000) performed Chiropractic research assessing the ANS and CVS using the ECG. The study involved one participant treated over a six week period. In their conclusion they suggested the changes that were detected in the ANS and CVS were due to SAT, however they recommended further development of a reliable and reproducible experimental protocol before validating the effects of spinal adjustment therapy on these systems.

Further research was done at the Parker College of Chiropractic studying the effects of metronome breathing on the variability of autonomic activity measurements measuring respiratory rate, systolic blood pressure and using an ECG (Driscoll and DiCicco, 2000). They also recommended further research on the effect of spinal adjustment on the ANS and CVS using ECG as the monitoring device.

The fundamental basis for electrocardiography is that the electrical activation of cardiac muscle cells causes a depolarisation at the cell membranes. The depolarisation is transported along the length of the cell or fibre and transmitted to adjacent cells. The result is a moving "wave" of depolarisation which passes through the heart and sets up electrical activity (Haslett, Chilvers, Boon and Colledge, 2002).

As the cardiac impulses pass through the heart, electrical currents spread into the tissues surrounding the heart, and a small proportion of these spread all the way to the surface of the body. If electrodes are placed on the skin on opposite sides of the heart, electrical potentials generated by these currents can be recorded, amplified and displayed as an ECG. This can be graphically represented and interpreted (Rowlands, 1980).

The ECG contains valuable and accurate information about the activity in the heart's atria and ventricles. The ECG is further used to evaluate treatment and assess prognosis of various heart diseases (Haslett *et al.*, 2002).

The 12-lead Electrocardiogram is generated from the precordial chest and limb (seen in Figure 3.2) electrodes which allow a view of the heart from different directions. The electrodes are attached as follows: one electrode on each wrist and one electrode on each ankle, six more electrodes are placed on the anterior and lateral side of the chest over the heart (Rowlands, 1980). Proper attachment of the leads requires the skill to locate specific anatomical landmarks/locations, particularly the intercostal spaces (Phalen, 1996).

2.7.1 Rhythm analyis

Figure 2.3 illustrates a typical ECG tracing of one normal cardiac cycle which constitutes a P wave, QRS complex and a T wave. A tiny U wave may be present in 50 % to 70% of ECGs. The ECG's baseline voltage is called the isoelectric line. This is typically measured as the part of the tracing following the T wave and preceding the following P wave (Rowlands, 1980).

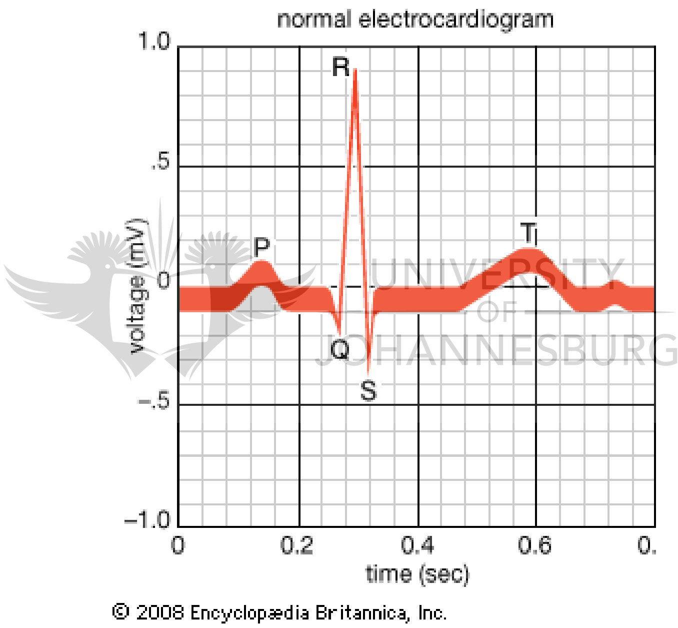


Figure 2.3: The Normal Eectrocardiogram of One Cardiac Cycle, http://cache-media.britannica.com/eb-media/95/26995-004-E5839E67.gif. (Accessed on 12 September 2009.)

Basic factors need to be identified when examining a patient's ECG, heart rhythm, eart rate, is the rate regular or irregular, inspect for the presence of P waves, QRS complexes, is the ratio between the P waves and QRS complexes normal and is the PR interval constant (Phalen, 1996).

2.7.2 P wave

During normal depolaristion at the atrium, the main electrical vector is directed from the SA node (SAN) towards the AV node (AVN) (Figure 2.4). This electrical vector spreads via the right atrium to the left atrium. On the ECG this is demonstrated as the P wave, which should be upright in leads II, III and aVF. The reason why the P wave ought to be upright, as is the case in the normal ECG, is due to the fact that the general electrical activity moves toward the positive electrode in leads II, III and aVF (Figure 2.3). The P wave should be inverted in the aVR lead because the general electrical activity is moving away from the positive electrode in the aVF lead. The P wave has to be upright in leads II and aVF and inverted in lead aVR to designate a cardiac rhythm as Sinus Rhythm. Abnormal shape and duration of the P wave may indicate atrial enlargement (Rowlands, 1980).

2.7.3 PR interval

The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex as is illustrated in Figure 2.3. Once again, abnormalities of the PR interval can be interpreted as various conditions such as early activation of the ventricles as seen in Wolff-Parkinson-White syndrome, atrial injury, pericarditis and many more cardiac diseases (Phalen, 1996).

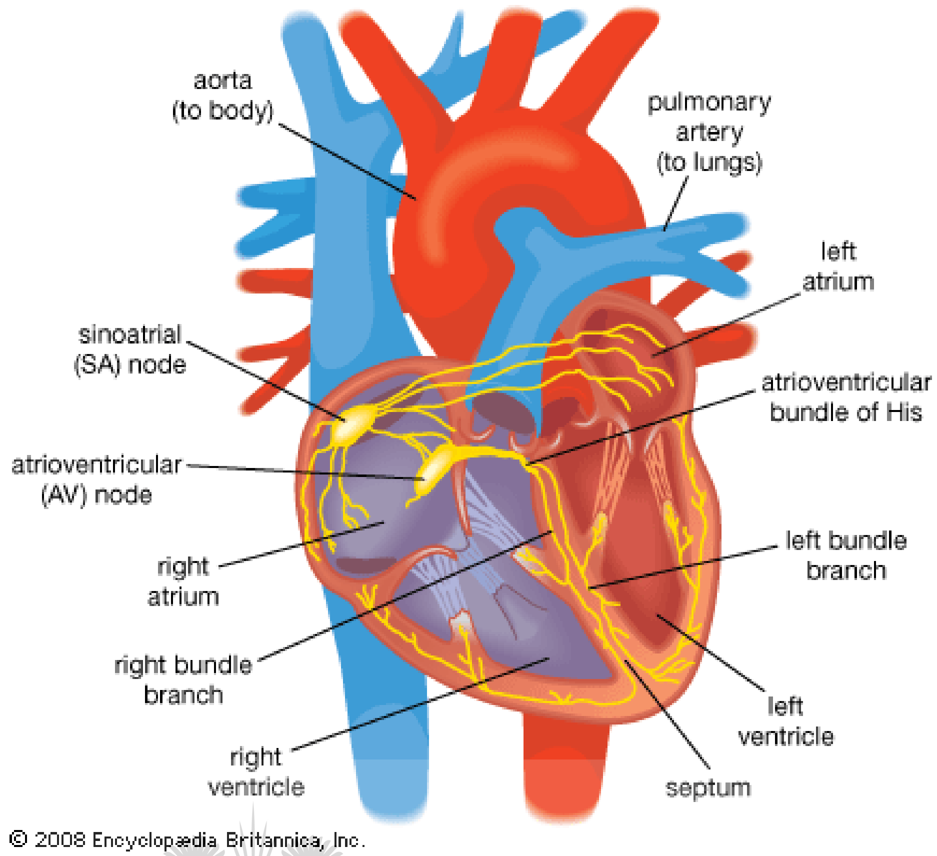


Figure 2.4: Illustration of the Heart and it's Electrical Conductance System, http://cache-media.britannica.com/eb-media/88/22488-004-F467622B.gif, (Accessed on 12 September 2009.)

2.7.4 QRS complex

The QRS complex on the ECG indicates the depolarisation of the ventricles as illustrated in Figure 2.5. Due to the anatomical difference between the ventricles and atria, in that the ventricles contain more muscle mass than the atria, the QRS complex is larger than the P wave. In addition, the QRS complex also has a spiked appearance rather than a rounded appearance as seen in the case of the P wave, due to the His/Purkinje system which co-ordinates the depolarisation of the ventricles and creates an increase in electrical conduction velocity (Figure 2.3). Abnormal QRS complexes are seen in conditions such as myocardial infarction, cardiac arrhythmias and ventricular hypertrophy amongst other diseases (Rowlands, 1980).

2.8 Previous Research

Chiropractic treatment is receiving increasing attention as more people turn to alternative medicine. Masarsky and Todres-Masarsky (2001) explain when practiced in its founding principles, Chiropractic is a system of practical vitalism. Such practitioners believe that the human body has an inherent capacity to heal itself, and that instead of fighting a disease or condition, the practitioner merely serves as a facilitator in the healing process. This thought process is parallel with the Hippocratic ethic of first doing no harm to the patient and then seeking to beneficially intervene (Masarsky and Todres-Masarsky, 2001).

The influence of the neurological systems on the heart has been of Chiropractic interest since the early days of the profession. Daniel David Palmer prescribed spinal adjustment of T4 for functional and organic disease of the heart and pericarditis. He introduced a method of Chiropractic analysis called "Nerve Tracing". This method uses digital pressure to follow a line of hypersensitive tissue from a specific painful or uncomfortable body part to the spine. Stemming from this information the Chiropractor would then suspect abnormal neurological function as a possible cause of dysfunction in all the tissues, somatic or visceral, innervated by the specific nerve. For example, when a patient's symptoms included cardiac complaints, the practitioner would be acquainted with the heart as being innervated by spinal nerves originating from the upper thoracic spine as well as autonomic innervation from the Vagus Cranial Nerve (Masarsky and Todres-Masarsky, 2001). Following on this information the practitioner would examine the upper thoracic and cervical spine because the Jugular Foramen in the cranium transmits the Vagus and Glossopharyngeal Nerve (Moore and Dalley, 2006). If dysfunctional spinal segments were found, the practitioner would restore the mobility of the indicated segments (Masarsky and Todres-Masarsky, 2001).

Chiropractic research has covered the cardiovascular topic numerous times (Budgell and Hirano, 2000; Driscoll and DiCicco, 2000; Knutson, 2001) and in previous studies Sphygmomanometry was the primary tool to assess changes in brachial arterial blood pressure (Driscoll and Hall, 2000; Knutson, 2001).

In 1988, Yates, Lamping, Abram and Wright used Sphygmomanometry and found that participants with elevated systolic and diastolic blood pressures (>130 mmHg and >90 mmHg respectively) showed an average reduction of 15 mmHg and 13 mmHg respectively, following adjustment of the thoracic vertebral segments (T1 – T5) using a mechanical adjustment device. Another case study performed by Plaugher and Bachman (1993), using the Sphygmomanometer, also indicated that Chiropractic adjustment therapy normalises arterial pressure.

McKnight and DeBoer (1988) found in a study of normotensive participants between the ages of 25 and 30 years, that an upper cervical adjustment resulted in an average 3 mmHg reduction of systolic and diastolic blood pressure. In contrast to the McKnight and DeBoer study (1988), Nansel, D., Jansen, R., Cremata, L., Bhami, M. S. and Holley, D. (1989) found no significant arterial pressure reductions in normotensive participants between the ages of 22 and 37 years following a lower cervical adjustment. The difference between these two studies lies within the region of adjustment in the cervical spine. McKnight and DeBoer (1988) adjusted the upper cervical spine which is associated with parasympathetic stimulation of the heart. Parasympathetic (Vagal) stimulation decrease heart rate, contraction force and cardiac output (House *et al.*, 1979). Nansel *et al.* (1989), in contrast, adjusted the lower cervical spine. The lower cervical spine and thoracic segments T1 – T5 are associated with the sympathetic stimulation of the heart. Sympathetic stimulation increases heart rate, contraction force and cardiac output (House *et al.*, 1979). Therefore it is clear why Nansel *et al.*, (1989) did not achieve the same result as the McKnight and DeBoer (1988) study.

The ECG has been shown to be of clinical use in measuring physiological changes in the CVS and has also been used in Chiropractic research. The ECG has further been found to be the preferred tool to study the CVS instead of arterial tonometry equipment (Budgell and Hirano, 2000; Driscoll and DiCicco, 2000; Knutson, 2001). Electrocardiography allows for a more accurate and detailed study of potential changes to the ANS and CVS.

Previous Chiropractic research assessing the ANS and CVS using the ECG was done at the Parker College of Chiropractic in Dallas, Texas in 1998 (Driscoll and Hall, 2000). The study involved only one participant treated over a six week period. In their conclusion they suggested the changes that were detected in the ANS and CVS were due to SAT, however they recommended further development of a reliable and reproducible experimental protocol before validating the effects of spinal adjustive therapy on these systems.

Knutson (2001) found results that indicate significant decrease in systolic blood pressure in participants during palpation and vectored atlas adjustment in comparison with resting subjects. The study proposed that the drop in systolic blood pressure be due to stimulation of the cervicosympathetic reflex or moderation of muscle tone and elimination of the effects of the Pressor Reflex. The lack of randomisation, blinding and an adjusted control group were factors that weakened the findings.

The hypothesis was that the reactions of the CVS in conjunction with the ANS to SAT were due to stimulation of the cervicosympathetic reflex or moderation of muscle tone and elimination of the effect of the Pressor Reflex.
In terms of racial differences in participants, Pansky, De Paula, Antelmi, Vincenzi, Andre, Artes and Grupi in 1999 found the Mean Heart Rates of young Black male and female participants to be significantly lower than the Mean Heart Rates of young Caucasian male and female participants. They also found the difference was not present for the age groups of 35 years and older.

CHAPTER THREE - METHODOLOGY

3.1 Introduction

This chapter aims to describe the method of data collection, the collection methods, objective measurements and the Chiropractic techniques used in this study. It further explains the methods through which statistical analysis of the data was performed.

3.2 Selection Criteria

One hundred and twenty students and/or staff from the Doornfontein Campus of the University of Johannesburg between the ages of 18 and 30 years were recruited to partake in the study. Advertisements (Appendix A) were placed on the campus notice boards advertising free Chiropractic treatment for participants suffering with mild neck pain as part of a research study done by the Chiropractic Department at the University of Johannesburg. Mild cervical spinal pain and stiffness as a result of cervical spinal dysfunction is very common amongst the students, lecturers and administrative staff, and thus the academic environment at a university was an ideal place to recruit participants.

3.2.1 Inclusion criteria

Participants were screened by completing a full Case History (Appendix B), Pertinent Physical Examination (Appendix C), Cervical Regional Examination (Appendix D) and S.O.A.P. note (Appendix E). Participants with normal blood pressure of more than 110/70 mmHg and less than 140/90 mmHg, between the ages of 18 and 30 years were included in the study to avoid increased risk of heart disease which has a higher incidence in older participants. Participants were instructed to avoid the following activities for 24 hours before treatment: excessive exercise, tobacco and alcohol use, caffeine or other stimulants, stressful events i.e. exams or interviews (the reason for this being all of the above-listed activities cause a change in cardiovascular behavior and will thus have a profound effect on the results of the study). The participants who participated were to have had previous Chiropractic cervical adjustments in order to avoid being anxious about the adjustment, which could affect the results of the study.

3.2.2 Exclusion criteria

Participants with a history of cervical spine surgery, or who had a known anatomical abnormality of the cervical spine were excluded. Participants with a history of cervical trauma within the past three months or persistent symptoms from an earlier trauma, had a history of cancer, hypertension, heart disease, diabetes mellitus, vascular disease, stroke or positional vertigo, or a history of chronic or recurrent inflammatory disease were excluded. The participant was also excluded if overweight according to the Body Mass Index (BMI), which provides a guide to the best weight range for good health regardless of age, gender or body type (Davis, 2005). BMI is calculated as weight divided by height square. Participants with a BMI of greater than 26 were regarded as overweight and therefore excluded from the study. Pregnant participants or those using chronic medication that might affect the cardiac system were also excluded. Participants were also examined for the presence of carotid bruits or positional vertigo as these were contra-indications to partake in the study, and were tested for vertebrobasilar arterial insufficiency by performing a supine cervical extension rotation test. Participants were also excluded if they had any of the Contra-indications to Chiropractic Cervical Spinal Adjustment Therapy (Appendix F).

3.3 Method

The sample group consisted of 120 participants demonstrating upper cervical dysfunction and who qualified for the study, who were to read and sign the Patient Information and Consent form (Appendix G) and Patient Biographical Information Sheet (Appendix H). The Case History (Appendix B), Pertinent Physical Examination (Appendix C), Cervical Regional Examination (Appendix D) and S.O.A.P. note (Appendix E) were completed. The participants were monitored for 3 minutes before the Chiropractic SAT (this was to determine a baseline), at the time of the Chiropractic SAT and for 3 minutes after treatment (by means of the ECG). Throughout the course of the experiment the ECG was used to monitor the participant's cardiovascular responses. A marker was made on the printed ECG readings at which point the Chiropractic SAT was delivered. The Lateral Atlas Index technique was performed for the purpose of this study (Appendix J). The printed ECG readings were then collected and handed over to Dr. Elias Zigiriadis (M.D, F.C. Cardio (SA)), a Specialist Cardiothoracic Surgeon (Appendix L) at the Johannesburg General Hospital, who interpreted the ECG readings. Dr. Zigiriadis recorded his interpretation of the results on the Cardiac Specialist Questionnaire for Statistical Analysis and Data Evaluation (Appendix K) which was then used for statistical analysis.

3.3.1 Equipment used during the study

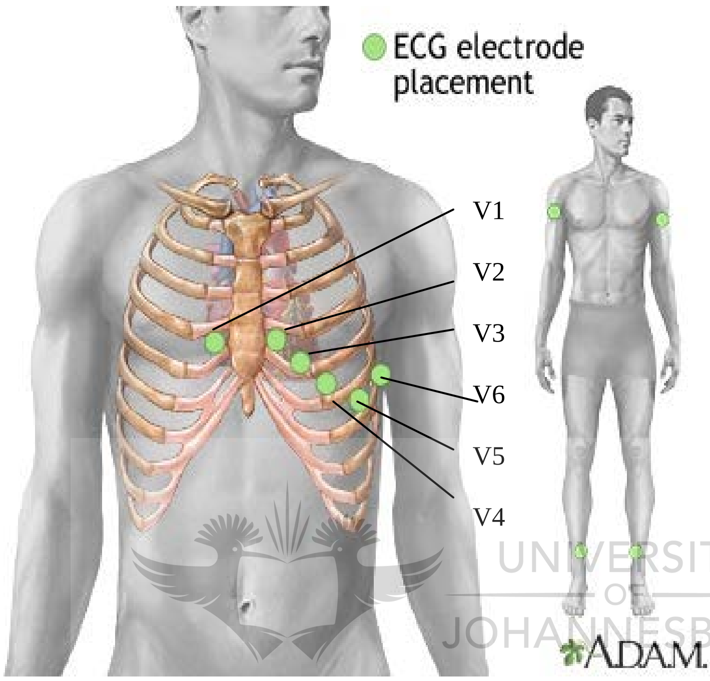
The researcher received training from the Emergency Medicine Department at the University of Johannesburg in the correct operating and attachment of electrodes of the equipment. A 12-lead ECG was used for the purpose of the study. The Anatomy and Physiology Department of the University of Johannesburg agreed that the researcher use the University of Johannesburg's 12-lead ECG equipment (Shiller AT5, Figure 3.1).

Figure 3.1: Schiller AT5 ECG Monitor, http://www.sortprice.com/reviews/read/ Schiller Cardiovit_at5 light_ECG_Machine, (Accessed 12 November 2008)

3.3.2 Placement of the precordial (chest) leads/electrodes

The V1 electrode is placed in the fourth intercostal space just right of the sternum (See Figure 3.2). V2 electrode is also placed in the fourth intercostal space but just left of the sternum. The next electrode, V4, is placed in the fifth intercostal space, in the midclavicular line. The remaining three electrodes are placed in relation to the position of V2 and V4. V3 electrode is positioned at the midpoint between V2 and V4 (Phalen, 1996).

From the position of V4 electrode, an imaginary horizontal line is drawn which is level with V4. The electrodes of V5 and V6 are placed on this imaginary line. V5 is positioned on the imaginary line and in the anterior axillary line (where the arm joins the chest). The last chest electrode, V6, is placed on the imaginary line and in the midaxillary line (Phalen, 1996).



Key:
V1 = 4th intercostal space, just right to sternum

V2 = 4th intercostal space, just left to sternum

V3 = midpoint between V2 and V4

V4 = 5th intercostal space in midclavicular line

V5 = horizontal level with V4 in anterior axillary line

V6 = horizontal level with V4 in midaxillary line
(Phalen, 1996)

Figure 3.2: Placement of the Precordial and Limb Leads
Modified from: http//www.nlm. nih.gov/medlineplus/ency/imagepages/19865.htm, (Accessed 12 November 2008.)

3.3.3 Placement of the limb leads/electrodes

Limb leads are placed anywhere on the appropriate limb (Figure 3.2), avoiding bony prominences. If the limb leads cannot be placed on a limb i.e. amputated arm or leg, the leads can be placed on the trunk as close as possible to a limb (Phalen, 1996).

3.4 Statistical Analysis

All the data collected during the study was tabulated. The ECG readings were analysed by the Specialist Cardiothoracic Surgeon (Appendix L) there after it was incorporated into the rest of the data. The full set of data was statistically analysed by Statcon of the University of Johannesburg in order to make the necessary findings. Repeated Measures Analysis, t-Test, Frequencies and Descriptives and Friedman's Tests were used in this quantitative study.

Although the initial study population consisted of 120 participants, it was discovered during statistical analysis of the data that 2 participants did not comply with the statistical requirements of the study and therefore only 118 participants were used in the final data evaluation process.

3.5 Ethical Considerations

Participants received, read, understood and signed the Patient Information and Consent Form (Appendix C) explaining all procedures and risks of the Chiropractic SAT. Participants had the right to anonymity and their privacy and confidentiality were protected at all times. Participants had the right to anonymity (their names were not used and they were allocated a number for statistical purposes), their privacy was protected (the examination and research procedures were performed in a private room) and their confidentiality was protected (all documentation remains in the Chiropractic Clinic at the University of Johannesburg). Participation in the study was completely voluntary and participants were free to withdraw at any stage.

CHAPTER FOUR - RESULTS

4.1 Introduction

The study population consisted of 118 participants with normal blood pressure demonstrating upper cervical dysfunction. The subjects were monitored for 3 minutes before the SAT (hereafter referred as Pre-adjustment), during (hereafter referred as Intra-adjustment) and for 3 minutes after treatment (hereafter referred as Post-adjustment) by means of the ECG. The printed ECG readings were then collected and handed over to the Specialist Cardiothoracic Surgeon, who interpreted the ECG readings.

The full set of tabulated data (Appendix K) was statistically analysed by Mrs J. van Staden at Statcon, University of Johannesburg. Repeated Measures Analysis, t-Test, Frequencies and Descriptives and Friedman's Tests were used in this quantitative study.

Statistical analysis and comparison was also made between male and female participants as well as a comparison between participants who received the SAT on the left side of the neck and those who received it on the right side of the neck.

4.2 Demographics

4.2.1 Age

The mean age of the participants was 24 years. The youngest participant was 18 years old and the oldest participant was 30 years old.

Fifty seven of the participants fell into the category of 18 to 23 years and 61 of the participants fell into the category of 24 to 30 years.

Figure 4.1 shows the age distribution of the participants in years. The highest to lowest number of participants of a specific age was 22 years followed by 19 years, 24 years, 29 years, 26 years, 30 years, 28 years, 18 years, 21 years and 27 years equally, 23 years, 20 years and 25 years equally as the lowest.

This distribution of the age groups was purely random.

18
16
14
12
10
8
6

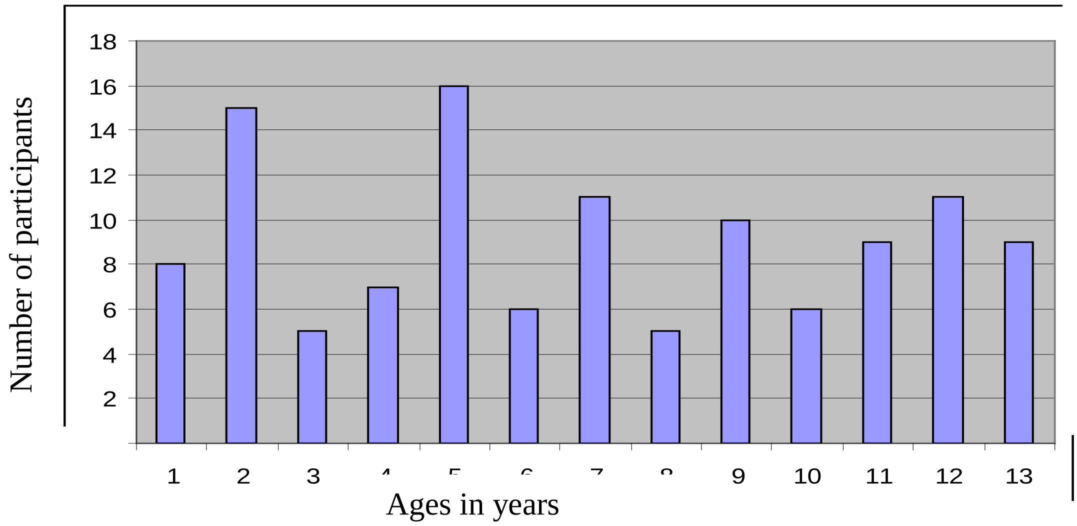


Figure 4.1: Bar Graph Representing Age Distribution

4.2.2. Gender

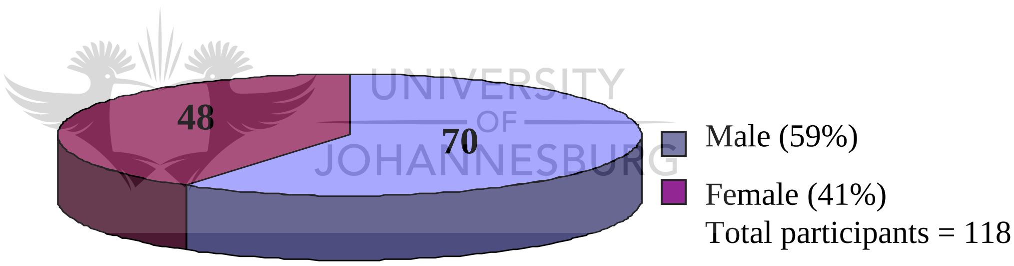


Figure 4.2: Pie Chart Representing Gender Distribution

Gender distribution of the sample group of 118 participants was as follows: 70 participants were male and 48 participants were female. See Figure 4.2.

4.2.3 Race

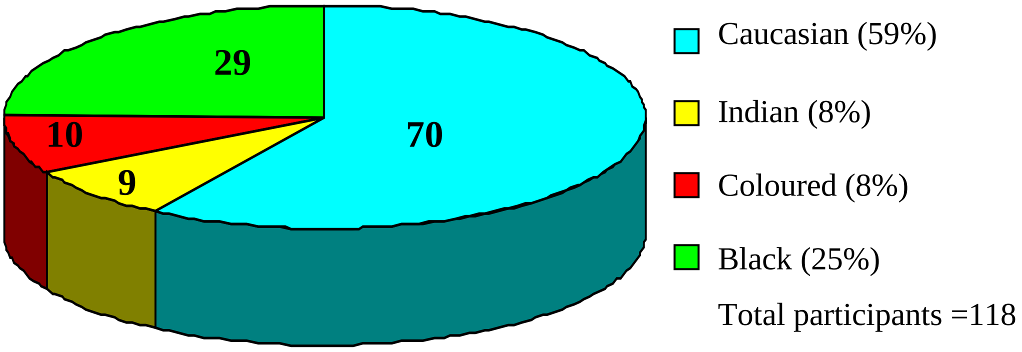


Figure 4.3: Pie Chart Representing Racial Distribution

The racial distribution of the sample group is shown in Figure 4.3. The number of Caucasian participants was 70 (59%), Indian participants were 9 (8%), Black participants were 29 (25%) and Coloured participants were 10 (8%).

4.3 Heart Rate

4.3.1 Average Heart Rate

Table 4.1: Average Heart Rate of the Sample Group over the Study Time Frame

	Mean (beats per minute)
Pre-adjustment	68.99
Intra-adjustment	68.36
Post-adjustment	66.96

Table 4.1 shows the average (Mean) heart rate of the sample group over time which was 68.99 beats per minute during 3 minutes Pre-adjustment phase, 68.36 beats per minute during Intra-adjustment phase and 66.96 beats per minute during 3 minutes Post-adjustment phase.

It can be noted that the heart rate decreased with on average 2.03 beats per minute from Pre-adjustment to Post-adjustment.

4.3.2 Difference in Heart Rate

Table 4.2: Intra-Group Analysis of Mean Heart Rate

	Mean Difference (beats per minute)	p-value
Pre-adjustment to Post-adjustment	1.985	0.000
Intra-adjustment to Post-adjustment	1.410	0.000

Table 4.2 is a comparison of the heart rate during Pre-, Intra- and Post-adjustment. The Mean Difference from Pre-adjustment to Post-adjustment was an average value of 1.985. It is also indicated that the p-value (Sig.) was 0.000 and is less than 0.05 therefore showing statistical significance.

The Mean Difference from Intra-adjustment to Post-adjustment was an average value of 1.410. It is also indicated that the p-value (Sig.) was 0.000 and is less than 0.05 therefore showing statistical significance.

4.4 Gender

4.4.1 Heart Rate of male participants versus female participants

Table 4.3: Mean Heart Rate of Male Participants versus Female Participants over the Study Time Frame

Gender of participant	Number of participants	Time of adjustment	Mean Heart Rate (beats per minute)	p-value
Male	70	Pre-adjustment	70.289	0.031
		Intra-adjustment	69.405	0.048
		Post-adjustment	68.024	0.088
Female	48	Pre-adjustment	69.560	0.005
		Intra-adjustment	69.219	0.011
		Post-adjustment	67.811	0.008

Table 4.3 shows the number of male participants were 70 versus the number of female participants which were 48.

It also shows the Mean Heart Rate of male participants was 70.289 beats per minute during the Pre-adjustment phase with a p-value of 0.031 indicating that the Mean Heart Rate is statistically significant (<0.05).

The Mean Heart Rate of male participants was 69.405 beats per minutes during the Intra-adjustment phase with a p-value of 0.048 indicating that the Mean Heart Rate is statistically significant (<0.05).

The Mean Heart Rate of male participants was 68.024 beats per minute during the Post-adjustment phase with a p-value of 0.088 indicating that the Mean Heart Rate is not statistically significant (p-value> 0.05).

Table 4.3 further shows the Mean Heart Rate of female participants was 69.560 beats per minute during the Pre-adjustment phase with a p-value of 0.005 indicating that the Mean Heart Rate is statistically significant (<0.05).

The Mean Heart Rate of female participants was 69.219 beats per minutes during the Intra-adjustment phase with a p-value of 0.011 indicating that the Mean Heart Rate is statistically significant (<0.05).

The Mean Heart Rate of female participants was 67.811 beats per minute during the Post-adjustment phase with a p-value of 0.008 indicating that the Mean Heart Rate is statistically significant (<0.05).

Table 4.4: Intra-Group Analysis Comparison Between Male and Female Participants

Gender of participant	Time frame	Mean Difference in Heart Rate (beats per minute)	p-value
Male	Pre-adjustment – Post-adjustment	2.265	0.000
Female	Pre-adjustment – Post-adjustment	1.749	0.000

Table 4.4 shows, for male participants, the Mean Difference in Heart Rate from Pre-adjustment phase to Post-adjustment phase is 2.265 beats per minute.

The p-value is 0.000 therefore the Mean Difference is statistically significant (<0.05).

It also shows, for female participants, the Mean Difference in Heart Rate from Pre-adjustment phase to Post-adjustment phase is 1.749 beats per minute.

The p-value is 0.000 therefore the Mean Difference is statistically significant (<0.05).

Table 4.5: Heart Rate of Male versus Female Participants Comparing Left and Right Sided Adjustment

Gender of participant	Right or Left sided adjustment	Number of participants	Mean Difference in Heart Rate (beats per minute)	p-value
Male	Right	43	2.398	0.004
	Left	27	1.007	0.053
Female	Right	27	1.782	0.013
	Left	21	1.399	0.029

Table 4.5 shows the number of male participants who were adjusted on the right side of the cervical spine was 43. The Mean Difference in Heart Rate was 2.398 beats per minute with a p-value of 0.004. The p-value is < 0.05 thus the Mean Difference in Heart Rate is statistically significant.

The number of male participants who were adjusted on the left side of the cervical spine was 27. The Mean Difference in Heart Rate was 1.007 beats per minute with a p-value of 0.053. The p-value is > 0.05 thus the Mean Difference in Heart Rate is not statistically significant.

The number of female participants who were adjusted on the right side of the cervical spine was 27. The Mean Difference in Heart Rate was 1.782 beats per minute with a p-value of 0.013. The p-value is < 0.05 thus the Mean Difference in Heart Rate is statistically significant.

The number of female participants who were adjusted on the left side of the cervical spine was 21. The Mean Difference in Heart Rate was 1.399 with a p-value of 0.029. The p-value is < 0.05 thus the Mean Difference in Heart Rate is statistically significant.

4.5 Heart Rhythm

Table 4.6: Table of Frequencies for Rhythm

	Rhythm Pre-adjustment	**Rhythm Intra-adjustment**	**Rhythm Post-adjustment**
	% of participants	**% of participants**	**% of participants**
Sinus Rhythm*	100%	98.3%	100 %
Abnormal Sinus Rhythm**	0%	1.7%	0%

**Sinus Rhythm: P-waves must be present, regular, the usual form for the specific patient, and its frequency must not be outside the range of 60-100 beats per minute. One P-wave to each QRS-complex. P-wave must precede each QRS-complex. The PR-interval must be normal, constant and QRS-complex must be the usual form for that patient (Rowlands, 1980).*

***Abnormal Sinus Rhythm: Patient may or may not have a pathological condition whereby one of the above mentioned measurements are not as required for Sinus Rhythm (Rowlands, 1980).*

Table 4.6 shows that 100% of the participants had a normal Sinus Rhythm during the Pre-adjustment phase, 93% had a normal Sinus Rhythm during the adjustment phase and 100% of the participants had normal Sinus Rhythm in the Post-adjustment phase. One point seven percent of participants showed an abnormal Sinus Rhythm during the Intra-adjustment phase. There were no significant changes in Rhythm frequencies in the participants.

4.6 P-Wave***

Table 4.7: Intra-Group Frequencies for P-Wave

	Pre-adjustment	**Intra-adjustment**	**Post-adjustment**
Seconds	**Percentage of participants (%)**	**Percentage of participants (%)**	**Percentage of participants (%)**
0.10	16.9	18.6	18.6
0.12	80.5	79.7	78.0
0.14	2.5	1.7	3.4

****P-wave is a small rounded deflection which is always upright in leads V3 to V6 and may be upright or biphasic in leads V1 and V2. Its total duration does not normally exceed 0.12 seconds.*

Table 4.7 shows 16.9% of participants had a P-wave of 0.10 seconds during Pre-adjustment phase, 18.6% had a P-wave of 0.10 seconds during Intra-adjustment and 18.6% had a P-wave of 0.10 seconds during Post-adjustment phase.

Eighty point five percent of participants had a P-wave of 0.12 seconds during Pre-adjustment phase, 79.7% had a P-wave of 0.12 seconds during Intra-adjustment phase and 78.0% had a P-wave of 0.12 seconds during Post-adjustment phase.

Two point five percent of participants had a P-wave of 0.14 seconds during Pre-adjustment phase, 1.7% had a P-wave of 0.14 seconds during Intra-adjustment phase and 3.4% had P-wave of 0.14 seconds during Post-adjustment phase.

4.7 QRS-Complex****

Table 4.8: Intra-Group Frequencies for QRS-Complex

	Pre-adjustment	Intra-adjustment	Post-adjustment
Seconds	**Percentage of participants (%)**	**Percentage of participants (%)**	**Percentage of participants (%)**
0.04	7.6	6.8	6.8
0.06	75.4	74.6	74.6
0.08	16.9	18.6	18.6

*****QRS-Complex is the time in seconds starting from the onset of the QRS complex to the end of the QRS complex whether or not the initial wave and/or final wave be negative or positive. The total QRS duration in any one precordial lead should not exceed 0.10 seconds (Rowlands, 1980).*

Table 4.8 shows 7.6% of participants had a QRS-Complex of 0.04 seconds during Pre-adjustment phase, 6.8% had a QRS-Complex of 0.04 seconds during Intra-adjustment and 6.8% had a QRS-Complex of 0.04 seconds during Post-adjustment phase.

Seventy five point four percent of participants had a QRS-wave of 0.06 seconds during Pre-adjustment phase, 74.6% had a QRS-wave of 0.06 seconds during Intra-adjustment phase and 74.6% had a QRS-wave of 0.06 seconds during Post-adjustment phase.

Sixteen point nine percent of participants had a QRS-wave of 0.08 seconds during Pre-adjustment phase, 18.6% had a QRS-wave of 0.08 seconds during Intra-adjustment phase and 18.6% had QRS-wave of 0.08 seconds during Post-adjustment phase.

CHAPTER FIVE – DISCUSSION

5.1 Introduction

This chapter serves to discuss the results found in the previous chapter. Reference is made to Chapters One, Two, Three and Four.

5.2 Demographics

5.2.1 Age

As seen in Chapter Three (3.2) and Chapter Four (Figure 4.1) the ages of the participants of this study ranged from 18 years to 30 years. The first reason for this age range was to exclude the participation of children and adolescents. It is well known that children have developing physiology which causes their heart rates to change as they age. The average heart rate of the newborn infant is 100 to 160 beats per minute, children between the ages of 1 and 10 years have an average heart rate of 70 to 120 beats per minute and from the age of 11 years into adulthood (including seniors) the average heart rate is 60 to 100 beats per minute (Seidel, Ball, Dains and Benedict, 2007). Hence, only 18 to 30 year old participants were included in this study.

Additionally using participants under the age of 18 necessitated parental consent which may have complicated the study further.

Secondly, the age range aimed to exclude participants who were older than 30 years old. Even though some studies have shown no difference in mean heart rate of younger and older adults (Ryan, Goldberger, Pincus, Mietus and Lipsitz, 1994), for the purpose of this study it was decided to only use a young adult group of younger than 30 years.

5.2.2 Gender

As seen in Figure 4.2, 70 participants were male and 48 participants were female. In Table 4.4 it can be seen that for male participants, the Mean Difference in Heart Rate from Pre-adjustment phase to Post-adjustment phase was 2.265 beats per minute in contrast to female participants whose Mean Difference in Heart Rate from Pre-adjustment phase to Post-adjustment phase was 1.749 beats per minute. The p-value for both male and female participants was 0.000 therefore the Mean Difference was statistically significant.

The difference in Mean Heart Rate between the two genders could possibly be explained by monthly hormonal fluctuations in females which is present in monthly menstrual cycles. In a study by Fagard and Reybrouck (1999) it was indicated that Mean Heart Rate of males versus females differed at a younger age when monthly menstrual cycles were present in the female participants, but not after the age of about 50 years or after the onset of menopause when menstruation ceases.

Table 4.5 also shows a tendency for the Mean Heart Rate to decrease more after SAT in both male and female participants who received the treatment on the right side of the cervical spine. It can also be seen that a similar tendency exist for the participants who received the treatment on the left side of the cervical spine to a lesser degree. The reduction in Mean Heart Rate for left-sided SAT is however significantly less than the reduction in Mean Heart Rate for right-sided SAT. It can be seen that the group of male participants treated on the left side was the only group whose reduction in Mean Heart Rate was not statistically significant (p-value > 0.05).

A possible explanation for the difference in the tendency of reduction of Mean Heart Rate in males versus females who received SAT on the left side of the cervical spine could be that the ratio of male participants versus female participants is 72:48 which is not the ideal 50:50 representation whereby a more accurate comparison can be drawn between the two genders. If the two groups had a 1:1 ratio, the outcome of the results may have been different whereby the tendencies would be a more accurate representation.

A further possible explanation for the above-mentioned discrepancy in the change of Mean Heart Rate could be that female participants exhibit significantly less muscle strength, neck girth and head mass resulting in lower levels of neck-head stiffness compared to that of the male participants as supported in research done by Tierney, Sitler, Swanik, Swanik, Higgens and Torg (2005). The difference between male and female muscle strength could have played a role at the time of treatment. Furthermore it is known that right-handedness is more common than left-handedness, studies suggest that up to 90% of the world population are right-handed in contrast to left-handed people (Holder, 1997). Therefore, even though it is unknown how many right-handed and how many left-handed participants were treated on either the right or left side of the cervical spine, the right-handed dominance may be a possible explanation for the difference in results between left and right-sided treatments.

The reason for the tendency of Mean Heart Rate to decrease less in participants who received the treatment on the left side of the neck remains disputable due to a lack of studies and could be a topic for future research studies.

5.2.3 Race

Figure 4.3 shows the race distribution in the study which consisted of 59% Caucasian participants, 8% Indian participants, 25% Black participants and 8% Colored participants.

Although it was not the aim of the study to compare the Mean Heart Rates of the different race groups it was found in a study by Jehn (2009) that Blood Pressure and Heart Rate measured in daytime was similar in Black participants and non-Black participants. An interesting finding of the Jehn (2009) study was that the

Black participants's Blood Pressure and Heart Rate declined statistically significantly at night time.

In contrast to the Jehn (2009) study, Pansky, *et al*. (1999) found the Mean Heart Rates of young Black male and female participants to be significantly lower than the Mean Heart Rates of young Caucasian male and female participants. They also found the difference was not present for the age groups of 35 years and older.

5.3 Heart Rate

It can be seen in Table 4.1 that the Mean Heart Rate of the participants decreased with an average of 2.03 beats per minute from Pre-adjustment to Post-adjustment. This is a statistically significant change as can be noted from Table 4.2 (p-values < 0.05). Table 4.2 shows how the Mean Heart Rate already started decreasing from the actual delivery of the adjustment (Intra-adjustment) to Post-adjustment.

Explanations for the decrease of the Mean Heart Rate include the possible stimulation of the Superior Cervical Cardiac Branch of Vagus Nerve or even the Vagus Nerve itself (Figures 2.1 and 2.2) which may cause the parasympathetic effects on the heart, one of the effects being a reduction in Heart Rate (House *et al.*, 1979).

Research by Bolton *et al.* 1998 support a second explanation for the change in Mean Heart Rate which is the possible stimulation of the muscle spindles situated in the deep intervertebral muscles, golgi tendon organs and afferent nerves from Zygapophyseal joints in the upper cervical region where the adjustments were delivered (refer to section 2.3). This together with the counter-reaction of the Cervicosympathetic Reflex on the Vestibulosympathetic reflex possibly lowers Blood Pressure and Heart Rate.

Knutson (2001) found similar results in his study which indicated significant decrease in systolic blood pressure in participants during palpation and vectored atlas adjustment in comparison with resting subjects. The study proposed that the drop in systolic blood pressure was due to stimulation of the cervicosympathetic reflex or moderation of muscle tone and elimination of the effects of the Pressor Reflex.

A third explanation for the reduction in Mean Heart Rate is the elimination of the Pressor Reflex (refer to section 2.4). Previous studies support this possible explanation whereby it was found that cervical joint dysfunction is closely linked to abnormal muscle hypertonicity which is corrected after SAT (Thabe, 1986). Densely packed muscle spindles in the cervical spine are furthermore associated with postural muscle control which is affected negatively in the case of cervical joint dysfunction and muscle hypertonicity (Karlberg, *et al.*, 1995). Eventually the Pressor Reflex is initiated in these circumstances which involves the increase of Blood Pressure to overcome the increased demands on the muscle (Simons and Mense, 1998). Spinal Adjustive Therapy however was shown to eliminate the Pressor Reflex ultimately causing a reduction in Blood Pressure which possibly leads to a reduction in Heart Rate (Knutson, 1998).

5.4 Heart Rhythm

Table 4.6 showed that for 98.3% of the participants of the study a Sinus Rhythm was observed from Pre-adjustment to Intra-adjustment and Post-adjustment. Two participants (1.7%) showed changes from Sinus Rhythm during Pre-adjustment to an Abnormal Sinus Rhythm during Intra-adjustment. This abnormality however reversed back to Sinus Rhythm during Post-Adjustment. In further investigation of the two participants with Abnormal Sinus Rhythm it was seen that one of the participants had a Mean Average Heart Rate of 52 beats per minute during the treatment as well as a P-wave duration of 0.14 seconds. According to Rowlands (1980) some of the criteria for Heart Rhythm to be a Sinus Rhythm are that Heart Rate must not be outside the range of 60 to 100 beats per minute and that the P-wave duration not exceed 0.12 seconds.

The second participant with the Abnormal Sinus Rhythm had a normal Heart Rate but a P-wave duration of 0.14 as described above.

In general the SAT received by the participants did not cause significant changes in Rhythm frequencies in the participants. A possible reason for this could be that the decrease in Mean Heart Rate was not significant enough to cause changes in Heart Rhythm.

5.5 P-Wave

Table 4.7 shows Intra-group changes in the P-Wave duration (seconds). According to Rowlands (1980) the P-Wave is represented on the ECG as a small rounded deflection which should always be upright in leads V3 to V6 and may be upright or biphasic in leads V1 and V2. Normally the total duration of the P-Wave should not exceed 0.12 seconds.

It can be seen in Table 4.7 that the majority of the participants (78% - 80.5%) had a P-Wave duration of 0.12 seconds throughout the treatment process while a smaller number of participants (16.9% - 18.6%) had a P-Wave duration of 0.10 seconds throughout the treatment process. A very small group of participants (1.7% - 3.4%) had a P-Wave duration of 0.14 seconds. In general the SAT received by the participants did not cause significant changes in P-Wave duration. As with Heart Rhythm, a possible reason for this could be that the decrease in Mean Heart Rate was not significant enough to cause changes in the duration of the P-Wave.

5.6 QRS-Complex

Table 4.8 shows that the majority of the participants (74.6% - 75.4%) had a QRS-Complex duration of 0.06 seconds throughout the treatment process. A smaller group of participants (16.9% - 18.6%) had a QRS-Complex duration of 0.08 during the treatment process while a very small number of participants (6.8% -

7.6%) had a QRS-Complex duration of 0.04 seconds during the treatment. According to Rowlands (1980) the QRS-Complex duration should not exceed 0.10 seconds which did not occur during this study.

The SAT received by the participants did not cause a significant change in duration of the QRS-Complex. A possible reason for this could be that the decrease in Mean Heart Rate was not significant enough to cause changes in QRS-complex duration.

CHAPTER SIX – CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

As mentioned in Chapter One (section 1.2), the aim of this study was to determine the effect of Chiropractic Spinal Adjustment Therapy (SAT) of the upper cervical spine on the normal physiological reactions which take place in the ANS and CVS whilst using the Electrocardiogram (ECG) as a monitoring device. Objective measurements that were taken included heart rate, heart rhythm, P-interval and QRS-complex.

The results of this study as seen in Chapters Four and Five showed that Chiropractic SAT of the upper cervical spine in fact had an effect on the Autonomic Nervous System which then influenced the Cardiovascular System thereby causing a statistically significant decrease of 2.03 beats per minute in Mean Heart Rate.

A possible explanation for the decrease in Mean Heart Rate is the stimulation of the Superior Cervical Cardiac Branch of Vagus Nerve (House *et al.*, 1979). Secondly a possible reason for the decrease in Mean Heart Rate may be the stimulation of the Cervicosympathetic Reflex or moderation of muscle tone (Knutson, 2001) and thirdly the elimination of the effects of the Pressor Reflex (Knutson, 1998).

The results of this study however also showed that Chiropractic SAT of the upper cervical spine had no statistically significant effect on Heart Rhythm (section 5.4), P-Wave (section 5.5) or QRS-Complex (section 5.6). A reason for this may be that even though the decrease in Mean Heart Rate was statistically significant, the change in Mean Heart Rate was not large enough to have an effect on Heart Rhythm, P-Wave and QRS-Complex.

6.2 Recommendations

It is recommended that future studies on this topic use a larger sample group than 118 as was the case with this study. A group of at least 500 participants, for example, may provide better statistical outcome than that of a small group.

It is further recommended that future studies on this topic include either equal representation of male and female participants (section 5.2.2), or only one gender group such as males. A group containing only male participants will exclude the possible influence of female hormonal fluctuations on the Cardiovascular and Autonomic Nervous System since this may have an effect on the results of the study (Fagard and Reybrouck, 1999).

It is further recommended that future studies on this topic should focus treatments on one side of the cervical spine only, for example on the left side or only on the right side. Participants should be questioned on right-handedness and left-handedness. This information must be taken into consideration when interpreting the results of the study (Holder, 1997). The tendency as was seen in this study for the Mean Heart Rate to decrease less in participants who received the treatment on the left side of the neck is also a topic for future research studies since very little research material on this topic is available.

Future research on this topic should also include the exploration of the long term effects of the Chiropractic Spinal Adjustment on Mean Heart Rate. Instead of a 3-minute Pre-adjustment and Post-adjustment period the study should rather have a longer period such as an hour or even longer. Follow-up treatments could also be a valuable tool in the studying of long term effects.

Finally, research studies dealing with Cardiovascular System or Autonomic Nervous System should aim to guarantee a quiet, relaxed and regulated room temperature testing environment. Even a slightly noisy atmosphere or an uncomfortable room temperature may influence the physiological response of the participant which may ultimately have a negative effect on the results of the study.

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Appendix A

Advertisement

Come for free Chiropractic treatment!

DO YOU SUFFER FROM NECK PAIN OR STIFFNESS?

Participants must be between the ages of 18 to 30

University of Johannesburg

Chiropractic Day Clinic

Gate 7, Sherwell Road, Doornfontein

Contact Lynelle Van Tonder

082 225 3580

Appendix B

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

CASE HISTORY

Date: _______________

Patient: ____________________________ **File No:** __________

Age: ______ **Sex:** ___________ **Occupation:** ________________

Student: ________________________ **Signature:** ________________

FOR CLINICIAN'S USE ONLY

Initial visit clinician: __________________ **Signature:** ________________

Case History: ____

Examination:
Previous: UJ Other Current: UJ Other

X-ray Studies:
Previous: UJ Other Current: UJ Other

Clinical Path. Lab:
Previous: UJ Other Current: UJ Other

Case status:
PTT: Conditional: Signed off: Final sign out:

Recommendations:

Students case history

1. *Source of history:*
2. *Chief complaint:(patient's own words)*
3. *Present illness:*

Location
Onset
Duration
Frequency
Pain (character)
Progression
Aggravating factors
Relieving factors
Associated Sx's and Sg's

Previous occurrences
Past treatment and outcome

4. *Other complaints:*

5. *Past history*

General health status
Childhood illnesses
Adult illnesses
Psychiatric illnesses
Accidents/injuries
Surgery
Hospitalisation

6. *Current health status and lifestyle*

Allergies
Immunizations
Screening tests
Environmental hazards
Safety measures
Exercise and leisure
Sleep patterns
Diet
Current medication
Tobacco
Alcohol
Social drugs

7. *Family history:*
Immediate family:

Cause of death
DM
Heart disease
TB
HBP
Stroke
Kidney disease
CA
Arthritis
Anaemia
Headaches
Thyroid disease
Epilepsy
Mental illness
Alcoholism
Drug addiction
Other

8. *Psychosocial history:*

Home situation
Daily life
Important experiences
Religious beliefs

9. *Review of systems:*

General
Skin
Head
Eyes
Ears
Breasts
Respiratory
Cardiac
Gastro-intestinal
Urinary
Genital
Vascular

Appendix C

UNIVERSITY OF JOHANNESBURG

PERTINENT PHYSICAL

(Note: This form may only be used when you have completed 35 new patients)

Student Name: ______________________ Signature:_____________________________

Doctor Name:__________________________ Signature:_____________________________

Patient Information:

Name:_________________________________ Occupation:____________________

Age:__________________________________ Sex:_________________________________

Vitals:

Height: ______________________________ Weights:_______________________

Pulse Rate:____________________________ Respiratory Rate:_________________

Blood Pressure:_________________

	Inspection	Palpation	Percussion	Auscultation
Thorax				

	Inspection	Palpation	Percussion	Auscultation
Abdomen				
	Cranial Nerves	Motor System	Sensory System	Cerebellar System
Neurologic System				

Appendix D

UNIVERSITY
OF
JOHANNESBURG

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION
CERVICAL SPINE

Date: ______________________

Patient: _______________________ **File No:** __________________

Clinician: ________________________ **Signature:** ________________

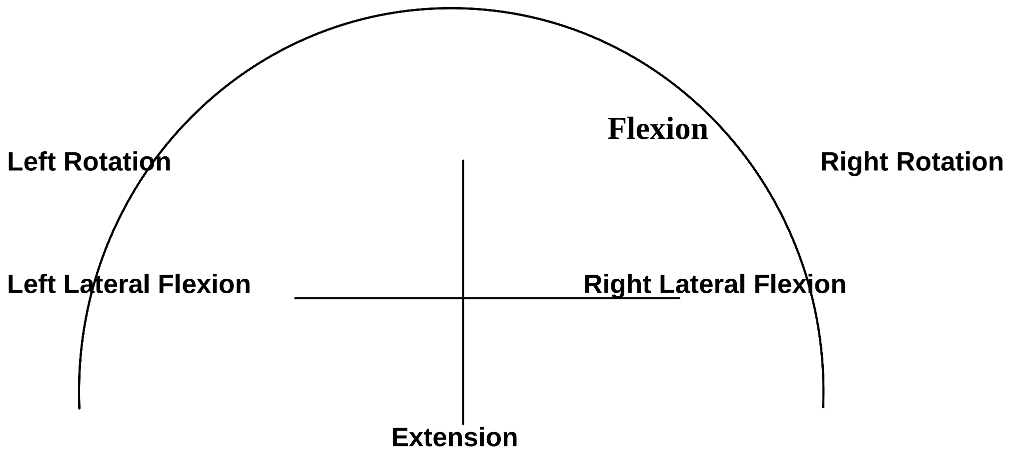
Student: ____________________________ **Signature:** ______________

OBSERVATION

Posture
Size
Swellings
Scars
Discolouration
Hairline
Bony and soft tissue contours
Shoulder level
Muscle spasm
Facial expression

RANGE OF MOTION

Flexion	=	45° - 90°
Extension	=	55° - 70°
L/R Rotation	=	70° - 90°
L/R Lat Flexion	=	20° - 45°



/ = Pain free limitation **// = Painful limitation**

PALPATION

- Lymph nodes
- Trachea
- Thyroid gland
- Pulses/thrills
- Tenderness
- Muscle Tone
- Active MF Trigger Points
  - SCM
  - Trapezius
  - Scaleni
  - Levator Scapulae
  - Posterior Cervical musculature

ORTHOPAEDIC EXAMINATION

1. Doorbell Sign
2. Max. Cervical Compression
3. Spurling's manoeuvre
4. Lateral Compression (Jackson's test)
5. Kemp's Test
6. Cervical Distraction
7. Shoulder abduction Test
8. Shoulder depression Test
9. Dizziness rotation Test
10. Lhermitte's Sign
11. O' Donoghue Manoeuvre

12. Brachial Plexus Tension
13. Carpal tunnel syndrome:
    - Tinel's sign
    - Phalen's Test
14. TOS:
    - Halstead's test
    - Adson's test
    - Eden's (traction) test
    - Hyperabduction (Wright's) test – Pec minor
    - Costoclavicular test

Remarks:

VASCULAR	LEFT	RIGHT
BLOOD PRESSURE		
CAROTIDS		
SUBCLAVIAN ARTERIES		
WALLENBERG'S TEST		

COMMENTS:

MOTION PALPATION

Jt. Play			Left					Right				Jt. Play		
P/A	**Lat**	**Fle**	**Ext**	**LF**	**AR**	**PR**		**Fle**	**Ext**	**LF**	**AR**	**PR**	**P/A**	**Lat**
							C1							
							C2							
							C3							
							C4							
							C5							
							C6							
							C7							
							T1							
							T2							
							T3							
							T4							

NEUROLOGICAL EXAMINATION

DERMATOMES	Left	Right	MYOTOMES	Left	Right	REFLEXES	Left	Right
C2			Neck Flexion C1/2					
C3			Lat. Neck Flexion C3					
C4			Shoulder Elevation C4					
C5			Shoulder Abduction C5					
C6			Elbow Flexion C5					
C7			Elbow Extension C7					
C8			Elbow Flexion at 90º C6					
T1			Forearm Pronation C6					
			Forearm Supination C6					
			Wrist Extension C6					
			Wrist Flexion C7					
			Finger Flexion C8					
			Finger Abduction T1					
			Finger Adduction T1					

Appendix E

UNIVERSITY OF JOHANNESBURG

CHIROPRACTIC DAY CLINIC

SOAP NOTE:

Patient:	Visit No:
File No:	Student:
Date:	Clinician:

S: O:

A: P:

Comments:

Patient:	Visit No:
File No:	Student:
Date:	Clinician:

S: O:

A: P:

Comments:

Appendix F

Contra-indications to Chiropractic Cervical Spinal Adjustments

- Acute Rheumatoid Arthritis in area of adjustments
- Acute fractures and dislocations or healed fractures and dislocations with signs of ligamentous rupture or instability
- Unstable Os-Odontoideum
- Benign bone tumors
- Malignancies
- Bone or joint infections
- Vertebrobasilar insufficiency syndrome
- Aneurysm of a major blood vessel in the area of adjustments
- Acute myelopathy in the area of adjustments
- Osteoporosis (Haldeman, 1992)

Appendix G

Subject Information and Consent form

The aim of this research project is to determine what the effect of an upper cervical spine adjustment has on the Autonomic Nervous System (ANS) and Cardiovascular System (CVS) in particular the heart. This research may improve the way we understand the way Chiropractic can influence these systems. It can also lead to further research on this topic which may eventually result in advanced treatment of disorders of the Autonomic Nervous System.

You have been invited to participate in this study. You will be required to undergo a pertinent physical and regional examination of your cervical spine. Your heart's activities will be closely monitored throughout the procedure by means of an Electrocardiogram. You will receive an appropriate Chiropractic upper cervical spine adjustment. You will be required to visit the Chiropractic Clinic at the University of Johannesburg only once, and no charges will be levied. You will at all times have the right to privacy, confidentiality and anonymity. Participation in this study is voluntary and you are free to refuse to participate or to withdraw your consent and discontinue participation at any time. You will remain anonymous and all information will be treated with confidentiality. A signed copy of this consent will be made available to you. You are free to contact me, should you at anytime have any queries concerning the study.

I have fully explained the procedures that will be used in this study and have explained their purpose. I have asked whether any questions have arisen regarding the procedures and have answered them to the best of my ability.

Date: _____________ Researcher: ______________________________________

I have been fully informed as to the procedures to be followed, including those that are investigational and have been given a description of the attendant discomforts, risks, and benefits to be expected and the appropriate alternative procedures. In signing this consent form I agree to this method of treatment and I understand that I am free to withdraw my consent and discontinue my participation in this study at any time. I also understand that if I have questions at any time, they will be answered.

Participant's name: ___________________________

Participants' signature: ________________________ Date: ____________________________

(Supervisor; Dr C. Hay; M. Tech. Chiropractic (TWR),

Co-Supervisor; Dr D van Aswegen; M. Tech.Chiropractic (TWR),

Researcher; Lynelle Van Tonder; Chiropractic Student.)

Appendix H

Patient Biographical Information Sheet

The purpose of this Information Sheet is purely for statistical analysis purposes. The information contained herein will be regarded as confidential.

Name: ____

Surname: ____

Gender: Female / Male

Date of birth: 19____/____/____

Identity number: ____

Race: ____

Date:_________________ Participant:___________________________________

Appendix I

Patient questionnaire regarding treatment experience

The purpose of this questionnaire is to serve a statistical purpose. Please be honest and rate your experience of the treatment.

	No	A little	Yes
Were you comfortable during the treatment?			
Were you nervous before the treatment?			
Were you nervous during the treatment?			
Was the treatment at any stage painful?			
Have you ever had Chiropractic treatment before?			

Any other comments:

____

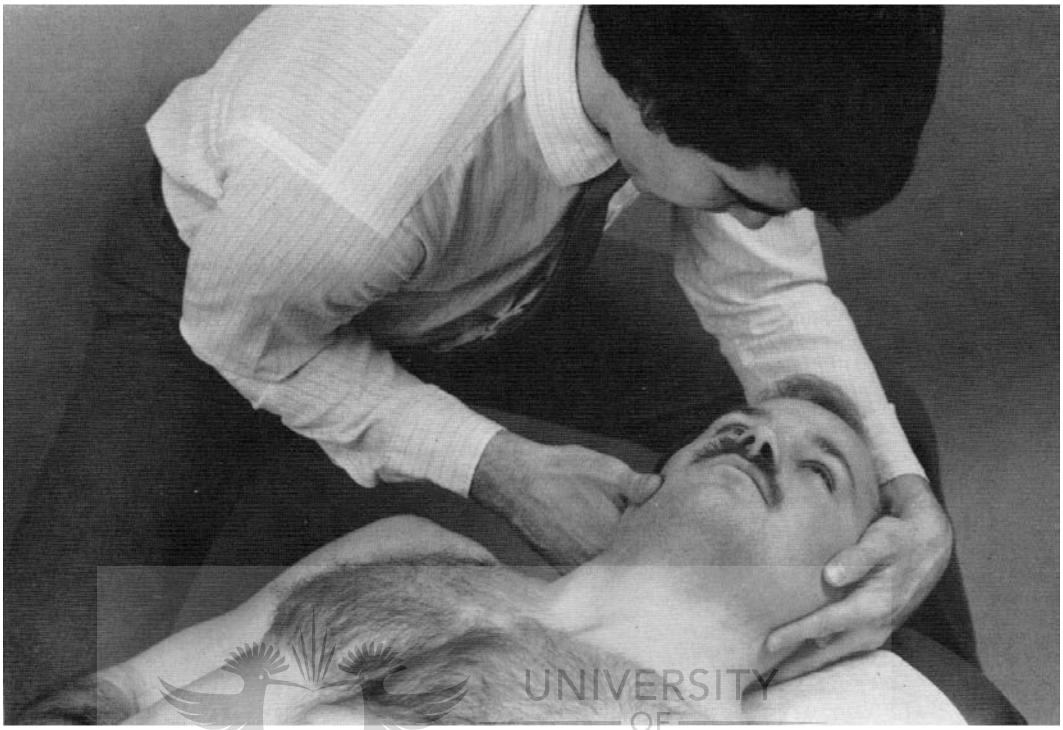
____

____

Date:_________________ Participant:____

Appendix J

Adjustment Technique



"Lateral Atlas Index"

This technique is indicated for a right and/or left laterally restricted atlas. The patient is positioned supine with the head remaining level to the headpiece and the nose pointing upwards. Doctor is positioned on the same side of the listing at the level of the patient's head. An index contact is taken on the apex of the transverse process of the atlas after skin slack was taken out from anterior to posterior. The Doctor's forearm remains parallel to the floor with wrist in ulnar deviation. Indifferent hand contact cups the ear and provide tractioning and support.

The adjustment is delivered at the end of expiration after inducing lateral flexion and driving the contact hand straight across in line with the patient's eyes.

Kirk, C.R., Lawrence, D.J. and Valvo, N.L (1985). *States Manual of Spinal, Pelvic and Extravertebral Techniques.* 2nd Edition. Illinois: National College of Chiropractic

Appendix K

Cardiac specialist questionnaire for statistical analysis and data evaluation

(Attached find the ECG results of the participant)

Name of participant:

Patient number:

Variables:

Heart rate	
Rhythm	
ST depression/elevation	
P-interval	
QRS-interval	

______________________________ ______________

Dr. Elias Zigiriadis (M.D, F.C. Cardio (SA) Date
Specialist Cardiothoracic Surgeon

Appendix L

Curriculum Vitae
Dr E. Zigiaradis

<u>Personal details</u>:
Date of Birth 13/10/64 Johannesburg, RSA
Languages English, Afrikaans, Greek

<u>Secondary education:</u>

Parkview Senior Primary School

Parktown Boys' High School (1978 – 1982)

<u>Tertiary education:</u>
MD, Athens University of Athens Medical School (Scholarship)

<u>Medical Council Registrations:</u>
- South Africa (full) MP0410888 (1994)
- GMC, UK (full) No. 4053284
- Hellenic Medical Council (full)
- Honorary Secretary Society of Cardiothoracic Surgeons of South Africa

<u>Employment History:</u>
- House Officer (01/01/94 – 31/12/94)
- Helen Joseph Hospital (4x4 Block) Surgery: Prof. Pantanowitz
  Orthopaedics: Mr. Ganz
  Int. Medicine: Prof. Variava
  Obs. & Gynae.: Dr S. Farber
- SHO Rotation: Prof. Davies (1995) – Johannesburg General Hospital
  Plastic & Recon. Surgery (3 months)
  Cardiothoracic Surgery (3 months)
  Trauma (3 mo. Including 6 weeks trauma ICU)
  Surgical ICU (3 mo.)
- Registrar: Chris Hani Baragwanath Hospital
- General I.C.U (18 beds)
  Jan. – June 1996
  Head: Prof. Lipman
- General Surgery: (July 1996 – December 1997)
  Head: Prof. R. Saadia

<u>Present post:</u>
Consultant & Lecturer Cardiothoracic Surgery, Witwatersrand University & Johannesburg Hospital
FC Cardio (SA) 2002

<u>Presentations at scientific meetings:</u>
<u>The South African Research Society</u>, Wits, 26 -27 July,2001

Vascular Rings- a 25 year experience (Zigiriadis.E, Vanderdonck.K,Cronje.S.L)
J.E.T in postop. Peadiatric cardiac patients (Zigiriadis.E,Vanderdonck.K, Cronje.S.L) AB180 CSS – Presentation of 2 patients with dilated CMO (Zigiriadis.E, Sussman.M, Cronje.S.L)

The South African Cardiac Society, San Lameer, 12-15 July, 2001 Vascular Rings – A 25 year experience

The South African Heart Association, Stellenbosch,12-15 November,2000

J.E.T – a troublesome complication (Zigiriadis.E,Vanderdonck.K,Cronje.S.L)

The South African Cardiac Society, Elephant Hills,Zimbabwe,October 1999 AB180 CSS- our experience (Zigiriadis.E, Sussman.M, Cronje.S.L)

The South African Pulmonology Society, Wild Coast, May 21-25,1999

Early Experience With Expandable Metal Stent Placement For Inoperable Carcinoma of the Oesophagus (Zigiriadis.E, Bizos.D.Cronje.s.l)

The Association of Surgeons of South Africa,ICC,Durban,June 10-14,1998

Early experience with self expanding metal stents for inoperable carcinoma of the oesophagus (Zigiriadis.E, Bizos.D)

The Bert Myburgh Registrars Research Forum, September 1998,Wits 2nd Prize

SCTSSA, Kruger Park, 2002

Ischaemic Mitral valve Reconstruction and replacement: A 16 year experience (Zigiriadis E, Colsen P, Kinsley R)

Study guides: Post resectional Empyema Trauma

Other academic:

- March 2006, Fellowship, The Alfred Hospital, Melbourne, Australia – Mechanical Cardiac Support
- Oscar Norwich Travelling Fellowship: 2003, Harefield, UK: Thoracic Organ transplantation and mechanical cardiac support
    - Mitral valve repair academy,Geneva,Switzerland,February 2007
- 25 -27 May ,2001, Training the Trainers (from Royal College of Surgeons of England)
- Wet Lab. –Toronto SPV (Stellenbosch),2000
- Paediatric cardiac society symposium,1999 Morningside
- Research techniques for beyond the Millennium (EXPD 701) 1998
- Laparoscopic workshop- Ethicon 1997
- Basic Skills Workshop -1996
- Surgical Critical Care Symposium –Baragwanath Hospital,1996
- ATLS and ACLS – 1995
- 1992 – Int. College of Surgeons, Greek section "Vascular Surgery & Endoscopic Technology"
- 1990 - Int. college of Surgeons Greek section annual symposium "acute Abdomen "