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The Effects of Thermotherapy versus Spinal Manipulative Therapy on Hypertonic Trapezius Muscles

A Dissertation submitted in partial fulfilment with the requirements for the degree

Masters of Technology

In Chiropractic

In The Faculty of Health Sciences

By Nicolaos Kalogeropoulos

Supervisor: Dr W S Long
Co-Supervisor: Dr A J Deall

At the Technikon Witwatersrand

September 2000
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ABSTRACT

It is hypothesised that hypertonic musculature can be treated by a variety of modalities which include thermotherapy, adjustment, dry needling, ultrasound and interferential current. In the present study, a sample of sixty subjects were randomly divided into three groups, the heat group, the adjustment group and the stretching group in order to evaluate which treatment modality was most beneficial in the short term management of trapezius muscle hypertonicity. Each group contained twenty subjects, respectively. At the initial consultation, a case history, a cervical regional and physical examinations were performed on each subject and each subject completed an informed consent form, Neck Pain and Disability Index (Vernon-Mior) questionnaire and a numerical pain rating scale. The subjects were treated once a day for four consecutive days, and were required to return one week after their last treatment for electromyographic recordings only. Electromyographic recordings were taken before the commencement of the treatment and on completion of the treatment on each day, including the follow-up.

Subjects in the heat group received heat packs followed by stretching of the trapezius musculature bilaterally. Subjects in the adjustment group received spinal manipulative therapy to all fixations within the vertebral levels of C0 to T1, followed with stretching of the trapezius musculature bilaterally. Subjects in the stretching group received stretching of the trapezius musculature bilaterally.

Objective measurements for each subject included electromyographic recordings, taken prior and after each treatment and on the follow-up. The subjective measurements consisted of numerical responses to the numerical pain rating scale and the Neck Pain and Disability Index (Vernon-Mior) questionnaire, which was completed prior to the initial treatment and at the follow-up.

The Kruskal-Wallis One Way Analysis on Ranks was used to compare the three groups, among each other and within each group.
The results indicated that there was no statistically significant difference between the initial treatment and the follow-up session in the heat group and adjustment group with regards to electromyographic recordings. However, in the stretching group there was a statistically significant difference (p=0.0330) between the initial treatment and the follow-up session with regards to EMG recordings. With regards to the numerical pain rating scale, the adjustment group was the only group that showed a statistically significant difference between the initial pre-treatment and the follow-up. This resulted in the hypothesis having to be rejected. It was therefore concluded that thermotherapy did not seem to play a significant role in the management of hypertonic trapezius musculature.
DEDICATION

To my MOTHER and FATHER
With Love
ACKNOWLEDGEMENT

I would like to acknowledge Nicolaas Duneas for his time and dedication, for without you, research would not be possible.

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ABBREVIATIONS

- CNS- central nervous system.
- EMG- electromyography.
- GTO- Golgi tendon organ.
- MS- muscle spindle.
- MTP- myofascial trigger point.
- SMT- spinal manipulative therapy.
- SOAP- Subjective objective assessment plan.
- TM- trapezius muscle.
- TP- trigger point.
- TWR- Technikon Witwatersrand.
- VSC- vertebral subluxation complex.
DEFINITIONS

- A latent myofascial trigger point(s) (MTP) as defined by Travell (1983), is a focus of hyperirritability in muscle or its fascia that is clinically quiescent with respect to spontaneous pain; it is painful only when palpated. A latent TP may have all the other clinical characteristics of an active TP.

- An active MTP as defined by Travell (1983), is a focus of hyperirritability in a muscle or its fascia that is symptomatic with respect to pain; it refers a pattern of pain at rest and/or on motion that is specific for that muscle. An active TP is always tender, prevents full lengthening of the muscle, weakens the muscle, usually refers pain on direct compression, mediates a local twitch response of muscle fibres when adequately stimulated, and often produces specific referred autonomic phenomena, generally in its pain reference zone.

- Simons and Travell (1983) distinguish between TP’s and tender points. Tender points are areas of tenderness that may or may not be in muscle tissue, do not have palpable taut bands, and do not refer pain to adjacent areas (Travell, 1983).

- According to Gatterman (1990), manipulation is the passive manoeuvre in which specifically directed manual forces are applied to vertebral and extravertebral articulations of the body, with the objective of restoring mobility to restricted areas. Short lever manipulation incorporates high velocity thrust short amplitude directed specifically at an isolated joint.
CHAPTER ONE

THE PROBLEM AND ITS SETTINGS

1.1 Problem statement.

Trigger points (TP’s), namely latent TP’s, are often a source of pain and dysfunction in many patients, and are very often found to be associated with chiropractic fixations (Travell and Simons, 1983). No substantial evidence exists that compliments spinal manipulative therapy of the cervical spine, in the treatment of latent TP’s in the trapezius muscle.

There have been numerous studies on cryotherapy and stretching (Foster and Palastanga 1985, Lehmann 1982, Rigby 1964, Warren et al. 1971 and 1976), but very few on thermotherapy (Foster and Palastanga 1985, Lehmann et. al. 1970). The studies mentioned above neglected to use EMG recordings to assess tension in the musculature. They also used a goniometer, which does not isolate an individual muscle’s function.

1.2 Sub-problems.

1.2.1 Sub-problem one.

The first sub-problem was to evaluate the effectiveness of cervical spine adjustments in combination with stretching of the upper trapezius musculature in the treatment of hypertonic trapezius musculature, by means of a questionnaire and EMG recordings.
1.2.2 Sub-problem two.

The second sub-problem was to evaluate the effectiveness of thermotherapy in combination with stretching of the upper trapezius musculature in the treatment of hypertonic trapezius musculature, by means of a questionnaire and EMG recordings.

1.2.3 Sub-problem three.

The third sub-problem was to evaluate the effectiveness of stretching of the upper trapezius musculature in the treatment of hypertonic trapezius musculature, by means of a questionnaire and EMG recordings.

1.2.4 Sub-problem four.

The fourth sub-problem was to compare the results within each group and between the three groups in order to determine whether there were significant differences, in therapeutic potential.

1.3 Formulation of hypotheses.

This study attempts to determine the relative efficacy of SMT and thermotherapy in the treatment of hypertonic musculature. Hypotheses that were tested are shown below:

1.3.1 Hypotheses.

- It was hypothesised that thermotherapy in combination with stretching of the trapezius musculature would be more beneficial than SMT of the cervical spine in combination with stretching of the trapezius musculature.
1.3.2 Null hypotheses.

- It was hypothesised that there is no significant difference between thermotherapy in combination with stretching of the trapezius musculature and SMT of the cervical spine in combination with stretching of the trapezius musculature in treating hypertonic trapezius musculature.

1.4 Aims and Objectives.

The purpose of this study is to evaluate which treatment modalities viz. chiropractic spinal manipulative therapy, thermotherapy, and stretching, in terms of the patients perception of pain, function and objective electromyographic recordings, are most beneficial in the short term management of trapezius muscle hypertonicity.

1.4.1 Benefits of the problem.

- The outcome of this study may provide a more effective treatment protocol.

- In the long term, patients and doctors alike may benefit from the knowledge that using thermotherapy in combination with stretching as a home exercise together with interval visits to the chiropractor, may nullify their latent TP’s.

- Not only is it important for professionals to find the most effective treatment, but for the patient to become more self-sufficient in controlling their own injuries.
CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction to myofascial trigger points.

Voluntary (skeletal) muscle is the largest single organ of the human body and accounts for 40% or more of the body weight (Travell and Simons 1983, Gatterman 1990). Bardeen (1921) quoted the Basle Nomina Anatomica as recognising 347 paired and two unpaired muscles for a total of 696 muscles. Any one of these muscles can develop myofascial trigger points (MTP) that refer pain and other distressing symptoms, usually to a remote location.

In spite of the above statement muscles receive little attention in modern medical school teaching and medical textbooks (Gatterman 1990). The contractile muscle tissues are extremely subject to the wear and tear of daily activities, but it is the bones, joints, bursae and nerves on which physicians usually concentrate their attention.

The prevalence of MTP is extremely common and becomes a distressing part of nearly everyone’s life at one time or another (Travell and Simons 1983). Latent TP’s, which may cause stiffness and restricted range of motion are far more common than active TP’s (Travell and Simons 1983). Fifty percent of normal asymptomatic persons have latent TP’s on examination of the shoulder-girdle musculature (Hubbard and Berkoff 1993).

Jaeger (1989) evaluated whether “cervicogenic” headaches were due to myofascial pain and cervical spine dysfunction. Her conclusion was that myofascial trigger points may be an important pain-producing mechanism in cervicogenic headache and that segmental cervical dysfunction is a common feature in such patients.

The severity of symptoms from MTP’s ranges from painless restriction of motion due to latent TP’s, to agonising incapacitating pain caused by very active TP’s (Travell and Simons 1983).
The myofascial pain may begin acutely with an obvious cause of muscular strain, or may begin insidiously due to obscure chronic muscular overload. In either case, symptoms may continue for months or years, if the myofascial TP source of the pain is not recognised and treated (Travell and Simons 1983). This often, but not always, leads to the syndrome of chronic pain, which tends to become a way of life (Sternbach 1974), and may require treatment of the pain behaviour (Travell and Simons 1983), as well as the TP origin of pain (Travell and Simons 1983).

Patients who have suffered myofascial pain for months or years are likely also to have developed secondary depression and sleep disturbances, and to have restricted their activity and exercise. The ensuing restriction of body movement and the increased in psychic tension aggravate their TP’s, causing a vicious cycle (Travell and Simons 1983).

2.1.1 Myofascial trigger point pain is characteristically augmented:

1. by strenuous use of the muscle, especially in the shortened position.
2. by passively stretching the muscle. However, active stretch by voluntary contraction of the antagonist does not ordinarily cause pain; the muscle quickly learns to limit this movement. The patient is aware of the restricted range of motion and ‘weakness’, but rarely thinks of the affected muscle as painful.
3. during pressure on TP.
4. by placing the involved muscle in a shortened position for a prolonged period. Pain and stiffness are often at their worst when the patient gets out of bed in the morning, or when getting up from a chair after sitting immobile for a while.
5. by sustained or repeated contraction of the involved muscle.
6. during cold, damp weather, viral infections and periods of marked nervous tension.
7. by exposure to a cold draft, especially when the muscle is fatigued.
8. by cold packs continuously applied on the TP area. However, cold packs may afford some relief when applied to the pain reference zone. (Travell and Simons 1983)
2.1.2 Myofascial TP pain is decreased:

1. by short periods of rest.
2. by slow, steady passive stretching of the involved muscle, particularly when the patient is seated under a hot shower or in a hot bath.
3. when moist heat is applied over the TP.
4. by short periods of light activity with movement.
5. by specific myofascial therapy. (Travell and Simons 1983)

2.1.3 Perpetuating factors of myofascial trigger points.

Mechanical stresses perpetuate TP’s in most patients with persistent myofascial pain syndrome. The most common sources of such physical stress are skeletal asymmetry and disproportion. Asymmetries include a short leg and a small hemipelvis. Skeletal disproportions are a long second metatarsal bone and short upper arms. Other sources of muscular stress, such as misfit furniture, poor posture, abuse of muscles, constricting pressure on muscles and prolonged immobility, are frequently significant and nearly always correctable. (Travell and Simons 1983)

Misfitting furniture, include prolonged sitting in a chair not designed for comfort, or in a well designed chair used for the wrong purpose, quickly tires and strains muscles. Here are some common faults of most household chairs as listed by Travell and Simons (1983), 'no support for your lower back; armrests are too low or too high; too scooped a back rest in its upper portion; backrest nearly vertical; backrest short; failing to support your upper back; high front edge of the seat, shutting down circulation in your legs; seat bottom soft in the centre, creating a bucket effect which places the load on the outer side of your thighs, rather than the bony points in the buttocks.

Poor posture contributing to continued TP activity is unphysiologic positioning at a desk or work surface and head tilt resulting from poorly adjusted reading glasses. People abuse muscles and thus perpetuate TP’s; by poor body mechanics that render movements
needlessly stressful, by sustained isometric contraction or immobility of the muscles, with too many repetitions of the same movement, and by excessively quick and jerky movements. A common example of poor body mechanics is leaning over while twisting sideways to lift an item from a shelf or the floor, another example is standing on one leg to put on a skirt or trousers is likely to strain gluteal and low back muscles. (Travell and Simons 1983)

Lack of movement, especially when a muscle is in the shortened position, tends to aggravate and perpetuate MTP’s. MTP’s are perpetuated by prolonged constricting pressure on a muscle, example, by the pressure from the strap of a ponderous purse hung over the shoulder (Engle 1978), or by narrow bra straps that support heavy breasts and groove the upper trapezius (Travell and Simons 1983).

Nutritional inadequacies are often crucial perpetuating factors. Low ‘normal’ levels of vitamin B1, B6, B12, and/or folic acid, are sub-optimal, and frequently are responsible when only transitory relief is obtained by specific myofascial treatment of involved muscles. Vitamin C deficiency causes post exercise stiffness and retards soft tissue healing; low levels of this vitamin are a rule in smokers. Adequate calcium, potassium, iron, and several trace minerals also are essential for normal muscle function. Borderline anaemia is an important factor. (Travell and Simons 1983)

Metabolic and endocrine inadequacies that commonly perpetuate TP’s are hypometabolism due to sub-optimal thyroid function, hyperuricemia and hypoglycemia. Psychological factors that inhibit rapid recovery include depression, tension caused by anxiety, the ‘good sport’ syndrome, secondary gain and sick behaviour. Chronic infection due to either viral or bacterial disease, and some parasitic infestations, can prevent recovery from myofascial pain syndromes. Other factors such as allergy, impaired sleep, radiculopathy and chronic visceral disease, prolong the treatment needed for recovery. (Travell and Simons 1983)
2.1.4 Treatment of myofascial trigger points.

Kraus (1970) discovered that spraying ethyl chloride on the skin relieves musculoskeletal pain. According to Travell and Simons’ (1983) experience, stretch and spray is the ‘workhorse’ of myofascial therapy. They also consider stretch as the essential component, while the spray facilitates stretch. Gentle persistent stretch without spray is more likely to inactivate TP’s than is spray without stretch. (Travell and Simons 1983)

Recently activated, acute, single-muscle TP syndromes may respond to passive stretch and hot packs without vapour-cooling. More chronic TP’s usually require both stretch and spray (Travell and Simons 1983). Obvious inadequacies of body structure that perpetuate TP should be corrected before proceeding with intensive TP therapy.

Post treatment muscle soreness is markedly reduced, by applying a hot pack for a few minutes immediately after stretch and spray. This re-warms the skin for re-treatment of the same area, if needed, and promotes further reduction of muscle tension. Dry heat applied to MTP is not as effective as wet heat. Moist hot packs are frequently applied to supine patients for treatment of low back and limb pain of myofascial origin. Moist heat tends to relax the underlying muscles and to diminish the tension of the TP, thereby reducing referred pain and local tenderness to pressure. (Travell and Simons 1983)

Procaine injection into the MTP is used effectively to relieve TP’s in muscles who’s attachments make it impossible to stretch, example, sternalis muscle. Injection is especially valuable when a few TP’s remain that are unresponsive to stretch and spray. (Travell and Simons 1983)

Dry needling, is precise needling of a TP, without injecting any solution. In Travell and Simons (1983) experience dry needling ‘approaches, but does not quite equal’ the therapeutic effectiveness of injecting procaine in TP. Kraus (1970) stated that dry needling is effective, but post injection pain follows immediately and lasts longer than procaine injection.
Ischaemic compression, which Prudden (1980) developed from the TP concept of Travell (1951) and Kraus (1970) involves sustained pressure to the TP with sufficient force and for long enough time to inactivate it. It is termed ischaemic compression because, on release, the skin is at first blanched, and then shows reactive hyperaemia. The changes in perfusion of the skin very likely correspond to the circulatory changes in the muscle beneath, which was subjected to the same pressure (Travell and Simons 1983).

Shiatzu or acupressure is a term used to describe a pressure version of acupuncture in which the operator applies digital compression in a manner similar to that described above for ischaemic compression. The spot for compression, however, is selected not for TP tenderness, but because of its location on an acupuncture chart. (Travell and Simons 1983)

Williams and Elkins (1942) found massage to be the single most effective treatment for myalgia (TP) of the head. Massage was more effective than heat alone, and a firm heavy, friction type massage was more effective than the stroking or kneading types. Beard and Wood (1964) considered kneading massage more effective than deep stroking massage within tissues. It is wise to use massage only if you have the knowledge to, as vigorous massage of hyperirritable TP can cause an adverse reaction with marked increase in pain, whereas if used for latent TP minimal referred pain is caused. (Travell and Simons 1983). Stripping massage technique is a specific stroking massage applied slowly and deeply, parallel to muscle fibres, this differs from Cyriax’s technique which is applied across the long axis of the muscle fibres (Cyriax 1980).

Many therapists find that application of ultrasound is an effective means of inactivating TPs (Travell and Simons 1983). Drug therapy should also be considered in the management of patients with myofascial pain syndromes. One must consider the role drugs have with respect to pain relief, muscular relaxation, sleep, depression, anti-inflammatory action, and adverse side effects. (Travell and Simons 1983)
2.2 Adjustment in the treatment of myofascial trigger points.

According to Greenman (1989), the term somatic dysfunction is now commonly used and includes skeletal dysfunctions that are often treated by manipulation. An understanding of the interface between myofascial pain syndrome and articular dysfunction is one of the great voids in our current knowledge of manual medicine (Travell and Simons 1992).

The facilitation of motor responsiveness caused by articular dysfunction is especially pertinent to the myofascial pain syndrome, but remains essentially unexplored with modern instrumentation (Travell and Simons 1992). Janda (1983) in association with others, has examined distortion of the normal sequence of co-ordinated motor activity associated with skeletal asymmetries and muscular imbalance. Lewit (1985) has emphasised the close clinical relationship between myofascial pain syndromes and articular dysfunction.

While the primary emphasis of chiropractic therapy is treatment by manipulation of joint dysfunction, concomitantly injured muscles, when left untreated, significantly prolong healing time and often result in unnecessary disability (Gatterman 1990). Travell and Simons (1992) further state that articular dysfunction and TP tension in related muscles can perpetuate each other, in which case, both conditions must be corrected to obtain lasting benefit.

Joint dysfunctions are more or less understood, but according to Janda (1983), joint dysfunction is an expression of the impairment as a whole, viz; both neuro-muscular and osteoarticular components of the body are involved. Kirkaldy-Willis and Burton (1992), also postulates the possible relationship between MTP’s and articular dysfunction or spinal fixations in his Myofascial cycle: (figure 2.1)
Emotional disturbance → Minor trauma

Muscles shortened/ weakened, fibrosis

Increasing muscle pathology

Vasoconstriction in muscle → Spasm

Changes in muscle

Multifidus abnormal contraction

Sustained contraction

Facet strain

Annular tears

Pathoanatomy: facet-disc interaction

Figure 2.1: The Myofascial Cycle showing relationship between MTP’s and articular dysfunction or spinal fixations, and pathological outcomes. (Kirkaldy-Willis and Burton 1992)
According to Haldeman (1992), back pain may be multifactorial in potential aetiology and pathogenesis. The flow diagram (figure 2.2), sums up the aetiology and progression.

Figure 2.2: Biomechanical dysfunction of spinal column and related structures. (Haldeman 1992, inside front cover)

From the flow diagram, one can see that common daily activity can cause back pain, viz: sitting in an office all day with the telephone squashed between the ear and the shoulder, poor posture by leaning the head forward staring into the computer screen, all of which result in muscle spasm, joint dysfunction, leading to pain and chronic disability. Furthermore systemic changes such as muscle spasm, neurochemical changes and visceral or autonomic responses may develop which result in even further pain and psychological disturbances.
Three primary mechanisms have been associated with the beneficial effects of spinal manipulative therapy (SMT or adjustment) for neck and back pain: mechanical, neurophysiological, and reflexogenic. Proponents of the mechanical mechanism argue that SMT causes a realignment of previously misaligned vertebral motion segments. This theory relies on the fact that SMT causes relative movements of adjacent vertebrae that has been shown to occur in selected treatments (Herzog et al. 1999). Proponents of the neurophysiologic mechanism believe that SMT triggers the release of endorphins or substance P. There is only isolated and contradictory evidence in support of this theory at present (Vernon et al. 1986, Christian et al. 1988, Sanders et al. 1990, Brennan et al. 1991). Finally, proponents of a reflexogenic mechanism argue that SMT causes a reflexogenic relief of pain (Herzog et al. 1999), and loss of hypertonicity in muscles of the target area (Herzog et al. 1999).

Herzog and co-workers (1999) state that spinal manipulative treatments typically elicited a general electromyographic response in most muscles of the neck and back. Of interest there was a 100% response in the right ascending aspect of the trapezius during SMT’s in the right cervical spine.

Herzog (1999) states that a reduction in hypertonicity might be supported if SMT caused an EMG response in the hypertonic musculature followed by a decrease in hypertonicity, evaluated by EMG. Gillette (1987), Haldeman (1986), and Wyke (1987) all support the notion that SMT has a beneficial treatment effect by inhibiting hypertonic muscles, reducing pain, and increasing functional ability. Shambaugh (1987) examined the effects of chiropractic adjustments on the trapezius and other muscles of the back. Using EMG Shambaugh (1987) concluded that SMT results in a reduction in muscle tension.

The mechanism by which pain is reduced is dependant on the source, with either the muscle or the joint, or both, being implicated as the source of pain. Immobility of joints results in physiologic changes in the muscle morphology and biochemistry (Gatterman 1995). This results in the muscle having increased spindle activity, resulting in an excessive stimulus to the central nervous system and altered efferent activity. This in
turn results in over stimulation of the muscle groups that responded to the stretch reflex with spasm and development of a tender TP (Gatterman 1990, Haldeman 1992). This effect on the muscle, due to immobilisation, is dependent on the length of immobilisation, and the angle the joint becomes fixed in (Gatterman 1990). It can be postulated that the joint fixations will result in a large muscular response that can ultimately result in increased pain and disability.

A mechanism by which chiropractic manipulation can affect this muscular dysfunction, via its influence on the muscle spindle activity, was postulated by Korr in 1978. He stated that the muscle spindles co-ordinate the amount of activity in the muscle and therefore increased activity in this system causes spasms, and therefore shortening of the muscle involved. Gamma motor neuron activity, which monitors base level muscle activity, now decreases. The muscle is now shortened and has no more input to the central nervous system, via the spindles. This results in an increase in the tone of the muscle, via gamma motor neurons under central nervous system (CNS) control, so feedback can be recognised to the central system, thereby perpetuating the spasm. The chiropractic adjustment, due to it being high velocity, would cause a rapid increase in the spindle activity causing a barrage of efferent impulses to the CNS. This results in decreased gamma motor neuron activity to normal levels resulting in normal muscle tone. (Gatterman 1995)

Spinal manipulation is hypothesised to produce significant short term bursts of proprioceptive transmission in the large-caliber myelinated alpha afferent fibres, arising from the spinal joint capsules and ligaments, and in the muscle spindles of the local paraspinal musculature. These large-fibre signals are believed to modulate the interneuronal pool via the dorsal spinal root ganglion and the substantia gelatinosa and to act to close the gate on pain transmission (Wyke 1987). Evidence exists that sensorimotor reflex connections are also influenced by manipulation via stimulation of the segmental motor pools (Vernon et al. 1986). Together, these effects may result in a reduction of both pain and muscle hypertonicity (Haldeman 1992).
The adjustment causes joint and muscle receptor stimulation (mechanical), causing relaxation of the paraspinal muscle (reflex). Wyke (1987) and others have shown that stimulation of mechanoreceptors by stretching of the joint has a reflex effect on the muscles over that joint, calming the muscle excitability and spasms that are often a part of low back pain. Bernard and Cassidy state, after their research on the sacro-iliac joint, that one could hypothesise that high-velocity, short amplitude manipulation forcefully stretches hypertonic muscles against their muscle spindles leading to a barrage of afferent impulses or signals to the CNS (reflex inhibition of gamma and alpha motor neurons therefore may lead to re-adjustment of muscle tone and relaxation). It might therefore be possible that manipulation affects joints by stimulating type 1 and type 2 articular mechanoreceptors as well as type 3 in the overlying ligaments. These impulses travel along the medium and large diameter nerve fibres and inhibit pain impulses travelling through the small diameter fibre.

DeBoer and co-workers (1988) obtained evidence for an effect of spinal lesions on gastrointestinal electromyographic activity in a recent experiment. Normal rabbits displaying normal gastric and duodenal EMG tracings from chronic implanted electrodes were used. Figure 2.3 illustrates a typical chart recorder trace from an undisturbed rabbit before manually applying a lesioning force designed to rotate and anteriorly displace a vertebra and thus simulate a somatic dysfunction, or subluxation. The type of force applied was very mild and the spinal lesion produced was putative. Gastrointestinal EMG activity was recorded during the entire period of the lesioning. Results clearly showed (figure 2.4) that this stimulus profoundly altered ongoing gut activity. Vertebral lesions were applied at T1, T6, T12, and L3 and, inhibition of gastric motility as measured by EMG activity was most clear at T6. Similarly cervical vertebral subluxations may have a profound effect on the neuronal output to the trapezius muscles.
Figure 2.3: Chart recording from the stomach of an undisturbed rabbit before manual application of lesioning force designed to rotate and anteriorly displace vertebrae to stimulate somatic dysfunction or subluxation. Top trace is raw unfiltered electromyogram showing slow-wave activity. Bottom trace is same signal filtered (1-1000Hz) to remove slow-wave activity and show spike activity. (Haldeman 1992, p121)
Figure 2.4: Gastrointestinal electromyographic activity (unfiltered, 0.03-1000 Hz) during the entire period of manual lesion (between arrows), which caused cessation of gut activity. Top trace from stomach, bottom trace from proximal duodenum. (Haldeman 1992, p122)
2.2.1 The vertebral subluxation complex and its significance in an adjustment.

Central to philosophy, science and practice of chiropractic is the vertebral subluxation. According to the definition agreed on by the nominal and Delphi panels of the Consortium of Chiropractic research, subluxation is defined as a motion segment in which alignment, movement integrity, and/or physiologic function are altered although contact between the joint surfaces remains intact. This is in contrast to the medical definition of subluxation, which involves an incomplete or partial dislocation. The VSC is defined as a theoretical model of motion segment dysfunction (subluxation) that incorporates the complex interaction of pathologic changes in nerve, muscle, ligamentous, vascular and connective tissue. (Gatterman 1995)

The current model of the VSC appreciates that when a spine is dysfunctional, all tissues are involved in such an interconnected way that it is impossible to discern where one tissue involvement ends and another begins (Lantz 1995).

Common to all concepts of subluxation are some form of kinesiological dysfunction and some form of neurological involvement. The primary form of kinesipathology that is addressed in chiropractic clinical practice is hypomobility, often referred to as fixation. Immobilisation degeneration is a term that refers to consistent patterns of degeneration in all tissues associated with an immobilised joint. There is considerable discussion as to whether partial immobilisation can lead to significant degenerative changes. Trauma, both severe and moderate, can contribute to subluxation. The VSC model presented here will deal exclusively with the neuromusculoskeletal components of spinal degeneration and dysfunction as related to the chiropractic concept of subluxation. (Lantz 1995)
Figure 2.5: Hierarchical organisation of the Vertebral Subluxation Complex. (Gatterman 1995, p152)

Figure 2.5, illustrates the hierarchical organisation of the VSC in which the components are seen in relation to one another. The kinesiological component is represented as the apex of the model because restoration of motion is the central goal in the clinical practice of chiropractic. This is the functional end point of the combined efforts of the tissue components. Movement is affected by the muscles (myologic component); guided, limited and stabilised by connective tissue; and controlled largely by the nervous system (neurologic component). The vascular system serves the essential nutritive and cleansing role for all tissues and is the conduit for the immediate stages of the inflammatory response. These constitute the tissue-level components of the VSC, and each work in co-ordination with the others to permit and sustain proper movement. Interference with any single component affects all others. Each tissue component has a role to play in spinal pathomechanics and the pathological processes associated with subluxation degeneration. (Lantz 1995)
2.2.1.1 Kinesiologic component of the vertebral subluxation complex.

The basic unit of spinal mobility is the motion segment, a three-joint complex. Functionally, it may be considered to be a single, compound joint with three articulations. A typical motion segment consists of two adjacent vertebrae joined by an intervertebral disc, two posterior articulations with their capsules and several ligaments. The muscles and segmental contents of the spinal canal and intervertebral canal are also included. (Lantz 1995, Gatterman 1990)

One of the most central tenets in chiropractic is the notion that restricted motion of the manipulative subluxation is central to spinal degeneration. All situations that lead to immobilisation cause some degree of degenerative change in the musculoskeletal system. Restoring motion to a previously immobilised joint leads to normal joint function and physiology. Although the degenerative effects of immobilisation may be completely reversed on remobilization, the extent of and time for maximal recovery are dependent on the duration of immobilisation. (Lantz 1995, Gatterman 1990)

2.2.1.2 Neurologic component of the vertebral subluxation complex.

The neurologic component of the VSC has traditionally been the cornerstone of chiropractic theory. The nervous system has been viewed as the mediator of health and vitality to all individual organs and tissues. The role of the nervous system in the subluxation complex is, far from understood and fundamental changes in the concept of neurologic involvement still need to be made. (Lantz 1995)

Spinal nerves may be impinged by herniated discs or by osteophytosis around the joints of Luschka. Nerve impingement from facet joint hypertrophy can also occur. The dorsal root ganglion lie within the intervertebral canal in close proximity to the articular capsule, except for the first and second cervical segments. Dorsal root ganglions contain all the cell bodies of all sensory neurons, except for those found in the cranial nerves. They are far more sensitive to mechanical stimulation than are nerve roots, spinal nerves or
peripheral nerves. When inflamed, the ganglia become hyperexcitable and give rise to spontaneous discharges. Minimal acute compression or chronic irritation lead to longer periods of repetitive firing that lasts longer than the stimulus itself; acute compression of peripheral nerves or nerve roots does not. Aberrant impulses could lead to clinical and pathological signs and symptoms. (Lantz 1995, Gatterman 1990)

2.2.1.3 Myologic component of the vertebral subluxation complex.

Muscles maintain osseous relationships as well as moving bones at their articulations. When joints are immobilised, the associated muscles undergo a degenerative process known as disuse atrophy. This is complicated by the fact that different muscle types respond differently to immobilisation. The type of degenerative response in the muscle is also related to the position of the joint and therefore the length of the muscle in the immobilised state. The muscle changes are secondary to joint changes in some cases, but in turn, also contribute to joint degeneration. In other instances, muscle pathology may be primary (such as trauma, congenital anomalies or diseases affecting muscles) which may subsequently contribute to joint degeneration. (Lantz 1995, Gatterman 1990)

Muscle spindles are adversely affected by immobilisation showing significant morphologic, physiologic and biomechanical changes, including shortening and thickening, degeneration of the primary muscle spindle endings, swollen capsules, and loss cross-striations. Physiologic alterations include increased sensitivity to stretch and elevation of resting rate of discharge. A consequence of such an increase in such muscle spindle activity would be to feed excessive stimuli into the central reflex pathways, resulting in altered efferent activity. This could lead to the over-stimulation of muscle groups that responded to the stretch reflex leading, in the end-state, to muscle spasm and tender active MTP. Alternatively, such input could lead to reflex inhibition or failure of joint musculature on challenge. (Lantz 1995)
2.2.1.4 Conclusion of the vertebral subluxation complex.

The VSC allows for every aspect of the chiropractic clinical management to be integrated into a single conceptual model. Each diagnostic procedure can be mapped into one or more components and specific therapeutic effects of adjustive or manipulative procedures can be assigned to specific tissue components or their elements. Each component can further be described in terms of precise details of anatomic, physiologic and biochemical alterations inherent in subluxation degeneration and parallel changes involved in normalisation of structure and function through adjustive or manipulative procedures. (Lantz 1995)

2.2.2 The sympathetic nervous system and its correlation between the adjustment and muscle tension.

Studies examining cardiovascular changes in normal subjects have suggested some activation of sympathetics by manipulation in the cervical spine, upper thoracic spine or lower thoracic spine regions. These studies have employed measures of heart rate and blood pressure as well as doppler pulse signal to assess autonomic nervous system. (Haldeman 1992)

Hubbard and Berkoff (1993) theorised that the TP EMG activity is generated from sympathetically stimulated intrafusal muscle fibre contractions.

The traditional teaching that there is no sympathetic innervation of muscle is no longer correct. The sympathetic nervous system innervates not extrafusal fibres, but intrafusal fibres. These unmyelinated axons had been recognised in muscle spindles but were not known to be of sympathetic origin or were assumed to be destined for blood vessels, not muscle fibres. (Hubbard and Berkoff 1993)

In a review article, Hubbard and Berkoff (1993) concluded “that the physiological as well as pathological states during which the sympathetic output is modified to be accompanied by changes in muscle tone. The peripheral sympathetic actions upon muscle spindles...
could then be in part responsible for these changes. The authors implied that muscle tension response to sympathetic stimulation was produced by intrafusal muscle contractions.

Sympathetic activation of intrafusal muscle fibres has not been studied in humans. There has been one study, however, that evaluated the effect of sympathetic blockage on TP's. Eight patients with primary fibromyalgia were studied before and after sympathetic blockage via stellate ganglion. The study reported a significant pain reduction in six of eight patients, and a significant reduction in the number of palpated TP’s. (Hubbard and Berkoff 1993)

Hubbard and Berkoff (1993) hypothesised that sympathetically stimulated intrafusal contraction causes an involuntary low-grade but symptomatic muscle tension. Prolonged or chronic spindle tension becomes painful by distending, distorting, or chemically sensitising the spindle capsule. Sympathetic activity explains the autonomic symptoms associated with TP’s and provides a mechanism by which local injury and nociception causes local tension, and by which emotional factors cause widespread tension and pain. This indirectly explains how the adjustment affects muscle tension by having an effect on the sympathetic nervous system.

2.3 Heat in the treatment of myofascial trigger points.

The physiological effect of heat is a rise in temperature, who’s main reactions are; increased metabolic activity, increased blood flow, and stimulation of neuronal receptors in the skin or tissues. These changes in the tissues may be produced by local, general or remote effects. (Foster and Palastanga 1985) The indirect effects of heating are muscle relaxation and an increase in the efficiency of muscle action, general rise in body temperature, decrease in blood pressure, and increased activity of sweat glands (Foster and Palastanga 1985).
Travell and Simons (1983) state that moist heat tends to relax the underlying muscles and to diminish the tension on the TP’s, thereby reducing referred pain and local tenderness to pressure. Travell and Simons (1983) also state that when a patient experiences reactivation of MTP’s that have been inactivated, sometimes, resting the muscle with application of heat may allow the muscle to recover within 72 hours without further therapy.

2.3.1 Heat’s mechanism of action.

2.3.1.1 Metabolism increases.

For every temperature rise of one degree C, there is a 13% increase in metabolism in the skin or muscle. Above 45 degrees C, tissue becomes damaged irreversibly (Gatterman 1990).

According to van’t Hoff, any chemical change capable of being accelerated is accelerated by a rise in temperature. Consequently heating of tissues accelerates the chemical changes, i.e. metabolism. The increase in metabolism is greatest in the region where most heat is produced, which is the superficial tissues. As a result of the increased metabolism there is an increased demand for oxygen foodstuffs, and an increase output of waste products, including metabolites. (Forster and Palastanga 1985)

2.3.1.2 Vasodilation.

At temperatures up to 42 degrees C, there is vasodilation of the skin and superficial fascia, with an increase in blood flow of four to five times the resting level. This vasodilation is caused by histamine-like substance acting on the capillaries as well as reflex action on the arterioles. Stimulation of superficial nerve endings can also cause a reflex dilatation of arterioles. As a result of the dilatation there is an increased flow of blood through the area, so that the necessary oxygen and nutritive materials are supplied and waste products are removed together with chronic inflammation. The superficial
vasodilation causes erythaema of the skin which, appears as soon as the part becomes warm and begins to fade soon after the exposure of heat ceases (Forster and Palastanga 1985). Vasodilation continues as the temperature rises above 42 degrees C, but burning becomes a danger.

2.3.1.3 Collagen extensibility increases.

At temperatures of 39-44 degrees C, the viscous properties of collagen become more dominant, and tension relaxes (Gatterman 1990). Tendons and capsular ligaments increase their ability to extend with stretch.

2.3.1.4 Sensory nerve endings are stimulated.

The sensation of heat is detected, and appears to produce definite sedative effects. The effects of heat on nerve conduction has still to be thoroughly investigated. Heat has been applied as a counter irritant, that is the thermal stimulus may affect the pain sensation as explained by the gate theory of Melzack and Wall (1965). It could also be explained through the action of endorphins (Lehmann 1982).

2.3.2 Effects of heat.

2.3.2.1 Analgesia effects of heat.

Pain relief is probably due to the stimulation of sensory nerve endings, causing a counterirritant effect and a decrease in transmission by pain fibres (Gatterman 1990).

2.3.2.2 Reduction of muscle spasm.

The effect is probably also mediated by the stimulation of sensory nerve endings, causing decreased firing of secondary nerve endings, resulting in decreased muscle tone. Vasodilation causing a release of waste products from the muscle may also contribute.
Rise in temperature induces muscle relaxation and increases the efficiency of muscle action, as the increase blood supply ensures optimum conditions for muscle contraction (Forster and Palastanga 1985).

Moist heat tends to relax the underlying muscle and to diminish the tension on the TP, thereby reducing referred pain and local tenderness to pressure. The patients active or passive stretch exercises at home are more effective if performed during or immediately after the application of moist heat (Travell and Simons 1983).

2.3.2.3 Oedema reduction:

Vasodilation increases capillary flow and the return of blood and lymph to the general circulation. However, heat may increase the trauma to the area and actually increase oedema, especially in an acute inflammation. (Forster and Palastanga 1985)

2.3.3 Contraindications for the use of heat.

Heat should not be use when the following symptoms are present, such as acute or subacute injuries, if haemorrhaging is present, when acute oedema is noted, circulation and sensation impairment, thermo-regulatory disorder and acute infection (Moreau 1993).

2.4 Stretching in the treatment of myofascial trigger points.

2.4.1 Stretching for muscular Relaxation.

One of the most important benefits of a flexibility program is the promotion of relaxation. From a purely physiological perspective, relaxation is the cessation of muscular tension. Undesirably high levels of muscular tension in the human organism result in several negative side effects. Excessive muscular tension tends to decreased sensory awareness of the world and raised blood pressure (Larson and Michelman 1973). It also wastes energy; a contracting muscle obviously requires more energy than a relaxed muscle.
Furthermore, habitually tense muscles tend to cut off their own circulation. Reduced blood supply results in a lack of oxygen and essential nutrients and causes toxic waste products to accumulate in the cells. This predisposes one to fatigue, aches, and even pain. Common sense and everyday experience shows that a relaxed muscle is less susceptible to these and many other ailments. (Alter 1988)

When a muscle stays partially contracted, an abnormal state of prolonged contraction called contracture develops. Contracture and chronic muscle tension not only shorten the muscle but also make the muscle less supple, less strong, and less capable to absorb the shock and stress of various types of movement. Consequently, undue muscular tension can produce excessive muscular tightness. Here, too, common sense indicates that the most appropriate remedy for such a disorder would be to facilitate muscular relaxation and immediately follow with some type of stretching. (Alter 1988). In support of this position, de Vries and Adams (1972) found exercise to be more effective than medication in decreasing muscular tension.

2.4.2 Stretching for relief of muscular soreness.

Everyday experience and research appears to indicate that slow stretching exercises can reduce and sometimes eliminate muscular soreness. Two types of pain are associated with muscular exercise: (a) pain during and immediately after exercise, which may persist for several hours and (b) delayed, localised soreness, which usually does not appear for 24 to 48 hours following exercise. Currently, there is still disagreement regarding the physiological cause or causes of muscular soreness and how stretching reduces or eliminates it. (Alter 1988 and Guyton 1991)

Regardless of the theoretical reasons for it, slow stretching has proven effective in reducing muscular soreness both during and immediately after exercise. For example, it is well known that a cramp is immediately relieved by stretching the involved muscle and holding the stretch. Furthermore, EMG recordings by de Vries (1966) have shown that static stretching relieves muscle soreness and significantly decreases electrical activity in the muscle to bring symptomatic relief. Similarly, static stretching appears to be effective in relieving delayed localised soreness.
2.4.3 The myotatic or stretch reflex.

Whenever a muscle is stretched, the stretch reflex mechanism is initiated. Stretching a muscle lengthens both the muscle fibres (i.e., extrafusal fibres) and the muscle spindles (i.e., the intrafusal fibres). The consequent deformation within the muscle spindles results in the firing of the stretch reflex, which contracts the muscle. This stretch effect can be divided into two components: phasic and tonic. The classic example of the phasic type of stretch reflex is the knee jerk or patella reflex. For example, when the patella tendon is given a light tap, the muscle spindles located in parallel with the muscle fibres are stretched, creating a deformation in the muscle spindles. As a result, the firing of the muscle spindle afferents is increased. The message is sent to the spinal cord (via the dorsal root) and brain. Completing the reflex arc, the spinal cord sends an efferent impulse to the quadriceps and causes them to contract, thus shortening the muscle and taking the tension off the muscle spindles. (Alter 1988 and Guyton 1991)

Another type of stretch reflex is the static, or tonic, stretch reflex. With this type of reflex the response to maintained stretch results in part from the effect of the secondary afferents. A common tonic response may be found in the postural reaction to stretch, exemplified by the contracting of the gastrocnemius to correct an excess shifting of one's centre of gravity while standing. (Alter 1988 and Guyton 1991)

2.4.4 Reciprocal innervation.

Muscles usually operate in pairs so that when one set of muscles, the agonistic, are contracting, the opposing antagonistic muscles are relaxing. This grouping of coordinated and opposing agonist and antagonist muscle is called reciprocal innervation. For example, when the arm is flexed at the elbow by action of the biceps contracting, the triceps muscle, which normally extends the arm at the elbow, must relax. If not, the two muscles would be pulling against each other and no movement would occur. In summary, when the muscle receives an impulse to contract, the other relaxes, because it does not receive an impulse to contract. It is therefore inhibited at the same instant that its antagonist contracts. Reflex inhibition is controlled by inhibitory discharge on the
motor neurons innervating the antagonistic muscle of the reciprocal pair. If the opposite muscle were similarly stretched, the other muscle would show inhibition by the same process. Without this reciprocal innervation, co-ordinated muscular activity would be impossible. (Alter 1988 and Guyton 1991)

2.4.5 The Golgi tendon organs.

The sensory receptor(s) that are responsible for detecting tension on a tendon are called the Golgi tendon organ (GTO). Its location is in the tendon near the ends of the muscle fibre. Because these organs lie directly in line with the transmission of force from muscle to the insertion on bone, they are said to be in series with the muscle, rather than in parallel as is the spindle. Consequently, they are stimulated by both passive stretch and contraction of the muscle. (Alter 1988). Originally, the GTOs were thought to function only as high threshold stretch or tension receptors, but this has been disproved. The GTO is known to be a tension receptor capable of monitoring all thresholds of muscle tension (Moore 1984). However, GTO’s are most sensitive to tension forces generated by muscle contraction. The GTO’s function as inhibitory mechanisms. The GTO’s, then, are an inhibitory afferent system, whereas the muscle spindle afferents are excitatory. The GTO’s operate in the following manner: when the muscle fibres contract, tension is produced. In turn, this tension pulls on the tendon. If the tendon is strong enough, it will activate the GTO’s. Then an impulse is transmitted to the spinal cord to inhibit nerve transmission in the anterior motor neurons. GTO’s have a much higher threshold than muscle spindle receptors. Therefore, ordinarily regular or moderate degrees of tension on the tendon do not stimulate the golgi receptors. In contrast to contraction, the degree of stimulation by passive stretch is not great because the more elastic muscle fibres take up much of the stretch. That is why it takes a strong stretch to elicit an inhibitory impulse. (Alter 1988)
Figure 2.6: Simplified scheme of possible variations in afferent discharge from Golgi tendon organs (GTO) and from muscle spindle primary or annulospiral receptors (AS) under various conditions of extrafusal relaxation, stretch, and contraction. Both TO and AS receptors are sensitive to passive stretching, although TO receptors have a higher threshold (A, B, and C). The TO receptors respond indiscriminately to extensive stretch (C) and to active extrafusal contraction (D and E). Active contraction relieves the tension on AS receptors (D), unless gamma efferent activity “resets” the tension within the intrafusal fibre (E). Intrafusal secondary or flower-spray receptors have been omitted here, although in actuality they add still another variable factor to the array of afferent information. (Alter 1988, p48)

2.4.6 The inverse myotatic stretch reflex or the autogenic inhibition.

If, however, the intensity of the contraction or stretch on the tendon exceeds a certain critical point, an immediate reflex occurs to inhibit the anterior motor neurons that innervate the muscle. As a result, the muscle immediately relaxes, and the excessive
powerful enough to override the excitatory impulses from the muscle spindles. This relaxation response to a strong stretch is called an inverse myotatic reflex or autogenic inhibition, and is a protective mechanism—a safety device to prevent injury to tendons and muscles. It prevents muscles and/or tendons from tearing away from their attachments. This may explain an interesting phenomenon that occurs when one is attempting to maintain a stretching position that develops maximum tension: that is, a point is suddenly reached where the tension dissipates and the muscle can be stretched even further. (Alter 1988 and Guyton 1991)

2.4.7 The static stretch.

Static stretching involves stretching the muscle to the point where further movement is limited and prevented by its own tension. At this point, the stretch is held and maintained for an extended period of time, during which relaxation and reduction of tension take place. This phenomenon has three possible explanations: First, the muscles stretch receptors (i.e., muscle spindles) become desensitised and subsequently adapt to stretch. Hence the stretch reflex is neutralised. Second, if the tension from the stretch is great enough, the autogenic inhibition reflex can be initiated. In turn, this will inhibit the muscle under stretch. Consequently, the muscles tension will decrease, thereby facilitating relaxation. The third and last explanation is based on the fact that the muscle and connective tissue possess time-dependent mechanical properties. That is, when a constant force is applied, creep or a progressive change in length occurs, along with stress relaxation, a progressive reduction in tension. Accompanying this change, too, would be a decrease in the discharge of the muscle spindle’s firings. (Alter 1988)

2.4.8 Properties of muscles under stretch.

When a tensile force is applied to connective tissue or muscle, the original length increases and its cross-section (i.e., width) decreases. Are there different types of forces, then, and/or conditions under which a force can be applied, that will create an optimal change in connective tissue and muscle? Sapega (1981) and co-workers answer the this
question and conclude that, when tensile forces are continuously applied to an organised connective tissue model (tendon), the time required to stretch the tissue a specific amount varies inversely with the forces used (Warren et al. 1971 and 1976). Therefore, a low-force stretching method requires more time to produce the same amount of elongation as a higher-force method. However, the proportion of tissue lengthening that remains after tensile stress is removed is greater for low-force, long duration method (Warren et al. 1971 and 1976, LaBan, 1962). Higher-force, short-duration stretching favours recoverable, elastic tissue deformation, whereas low-force, long-duration stretching enhances permanent, plastic deformation (Warren et al. 1972 and 1976, LaBan 1962). This principle does not necessarily rule out combining higher forces with a prolonged duration of stretch, but in the clinical setting, high-force application has greater risk of causing pain and possibly tissue rupture. In addition, laboratory findings have shown that when connective tissue structures are permanently elongated, some degree of mechanical weakening takes place, even though outright rupture has not occurred (Warren et al. 1971 and 1976, Rigby et al. 1959). The amount of weakening depends on the way the tissue is stretched as well as how much it is stretched. Of particular interest is that for the same amount of tissue elongation, a high-force stretching method produces more structural weakening than a slower, low-force method (Warren et al. 1971 and 1976).

Temperature has a significant influence on the mechanical behaviour of connective tissue under tensile stress. As tissue temperature rises, stiffness decreases and extensibility increases (LaBan 1962, Rigby 1964). Raising the temperature of tendon samples above 103 degrees Fahrenheit increases the amount of permanent elongation that results from a given amount of initial stretching (LaBan 1962). At about 104 degrees Fahrenheit a thermal transition in the microstructure of collagen occurs, which significantly enhances the viscous stress relation of collagenous tissue, allowing greater plastic deformation when it is stretched (Mason and Rigby 1963, Rigby 1964, Rigby et al. 1959). The mechanism behind this thermal transition is still uncertain, but it is thought that intermolecular bonding becomes partially destabilised enhancing the viscous flow properties of the collagenous tissue (Rigby 1964, Rigby et al. 1959).
When connective tissue is stretched at an elevated temperature, the conditions under which the tissue is allowed to cool can significantly affect the amount of elongation that remains after the tensile stress is removed. After the heated tissue has been stretched, maintaining tensile force during tissue cooling has been shown to significantly increase the relative proportion of plastic deformation compared with unloading the tissue while its temperature is still elevated (Lehmann et al. 1970). Cooling the tissue before releasing the tension apparently allows the collagenous microstructure to re-stabilise more toward its new stretched length (Lehmann et al. 1970).

When stretching connective tissue at temperatures within the usual therapeutic range (102 degrees to 110 degrees F), the amount of structural weakening produced by a given amount of tissue elongation varies inversely with the temperature (Warren et al. 1971 and 1976). This is apparently related to the progressive increase in the viscous flow properties of the collagen as it is heated. It is possible that thermal destabilisation of intermolecular bonding allows elongation to occur with less structural damage.

The factors influencing the visco-elastic behaviour of connective tissue can be summarised by stating that, elastic or recoverable deformation is most favoured by high-force, short duration stretching at normal or colder tissue temperature, whereas plastic or permanent lengthening is most favoured by low-force, longer duration stretching at elevated temperatures, but allowing the tissue to cool before releasing the tension. In addition, the structural weakening produced by permanent tissue deformation is minimised when prolonged, low-force application is combined with high therapeutic temperatures, and it is maximal when higher forces and lower temperatures are used.

Research by others (Becker 1979, Glazer 1980, Jackman 1963, Kottke et al. 1966, Light et al. 1984) has also demonstrated that stretching at low to moderate tension levels is effective.
2.4.9 Muscle stretch reflex.

The control of movement is dependent on proprioceptors providing the sensory info needed for a person's kinesthesia. The prime proprioceptors include the golgi tendon organ and the muscle spindle (MS). The MS consists of intrafusal fibres and extrafusal fibres. The stretch reflex is the contraction of an agonist muscle and the inhibition of an antagonist muscle as a response to the stretching of intrafusal fibres. The muscle spindle response will be a result of the velocity of the stretch and the length of the stretch (Klein 1999).

2.5 Anatomy of the Trapezius.

2.5.1 Attachments of the trapezius.

When the right and left trapezius muscle are viewed together from the rear, they form a large diamond shape. Together, like fibres of both upper trapezii are shaped like a coat hanger (Travell and Simons 1983).

Upper fibres.
The upper fibres attach above to the medial third of the superior nuchal line. In the midline, they attach to the ligamentum nuchae and to the spinous processes of the C1 through C5 vertebrae. Below the fibres diverge laterally and forward and attach to the outer third of the clavicle (Travell and Simons 1983).

Middle fibres.
These fibres attach medially to the spinous processes and interspinous ligaments of the C6 through to T3 vertebrae and laterally to the acromion and superior lip of the spine of the scapula (Travell and Simons 1983).
Lower fibres.
These fibres attach medially to the spinous processes and interspinous ligaments of the T4 through to T12 vertebrae. Laterally they ascend and converge onto the tubercle at the medial end of the spine of the scapular just lateral to the lower attachment of the levator scapulae muscle (Travell and Simons 1983).

Figure 2.7: Schematic representation of the Trapezius muscle (viewed posterior to anterior). C1 represents the attachment of the electrode. (Travel and Simons 1983, p187)
2.5.2 Trapezius muscle innervation.

Motor innervation of the trapezius muscle is supplied by the spinal portion of the spinal accessory nerve (cranial nerve XI). The trapezius portion of the motor nerve arises within the spinal canal ventral roots usually of the first five cervical segments; it ascends through the foramen magnum and exits the skull via the jugular foramen to supply, and sometimes to penetrate the sternocleidomastoid muscle. The nerve then joins a plexus beneath the trapezius. The plexus is joined by primarily sensory fibres from spinal nerves C2, C3, and C4; it supplies both the motor and sensory innervation to the trapezius muscle (Travell and Simons 1983).

Figure 2.8: Schematic diagram showing the trapezius muscle from the lateral view. C1 represents area of electrode placement. (Travell and Simons 1983, p188)
2.5.3 Actions of the trapezius muscle.

Summarising trapezius effect on scapular motion: elevation of the scapula activates the upper and middle trapezius fibres; retraction (adduction) activates all of its fibres; depression employs the lower fibres; and rotation involves chiefly the upper and lower fibres (Travell and Simons 1983).

Entire muscle.

Acting unilaterally, the trapezius rotates the scapula to direct the glenoid fossa upward, elevates and retracts the scapula, and extends the head and neck while rotating the chin to the opposite side. Acting bilaterally, the entire muscle assists extension of the cervical and thoracic spine. (Travell and Simons 1983)

Upper trapezius.

Acting unilaterally, this portion of the muscle elevates the shoulder, bends the head and neck laterally towards the same side, and aids in extreme rotation of the head to the opposite side. It usually helps to carry the weight of the upper extremity during standing, or to support the weight in the hand with the arm hanging. In conjunction with the levator scapulae and upper digitations of the serratus anterior, the upper trapezius provides the upper component of the force couple necessary to rotate the scapula, (glenoid fossa upward). Acting bilaterally, the upper fibres may extend the head and neck, but only against resistance. (Travell and Simons 1983)

Middle trapezius.

The middle fibres adduct and therefore retract the scapula (i.e., move it towards the midline). They also assist flexion and abduction of the arm at the shoulder, especially near its full range, by helping to rotate the scapula so as to tilt the glenoid fossa upwards. (Travell and Simons 1983)
Lower trapezius.
The lower fibres retract the scapula and rotate the glenoid fossa upward by depressing the vertebral border of the scapula; these fibres also assist flexion and abduction of the arm (Travell and Simons 1983).

2.5.4 EMG reading activity of trapezius muscle during certain sports.

EMG monitoring of the upper, middle, and lower trapezius fibres with surface electrodes was performed during 13 sports activities, including right-handed overhand throws, underhand throws, tennis, golf, and one-foot jumps in basketball (Travell and Simons 1983). All records show the motor unit on the left side to be equal to, or greater than, that on the right side, predominantly in the middle and lower trapezius fibres. The recording of the basketball throw showed this effect most strongly. The timing of the response suggested that this strong burst of left-side activity of the middle trapezius helped to extend rapidly the left upper extremity to balance rotational movement around the long axis of the body, as the right upper extremity approached the end of its power stroke. (Travell and Simons 1983)
CHAPTER THREE

METHODOLOGY

The patients were advertised for in the local newspaper and on the notice boards on the Technikon Witwatersrand (TWR) campus. The research study was explained to the patients and those willing to participate were required to sign a consent form (Appendix A).

All patients whom participated in this study underwent a case history, pertinent physical and cervical regional examinations (Appendices B, C, and D, respectively). The examinations included any contraindications to manipulation, stretching and heat. Contraindications such as positive Wallenbergs, gross degeneration, neoplasm, intoxication, trauma, congenital malformations, psychogenic disturbances for the adjustment (Haldeman 1992, Gatterman 1995), excessive pain, acute injury, lack of stability, disease of soft tissue, inflammation or infection for stretching (Doran 1998), and for the use of heat, such as, acute or subacute injuries, if haemorrhaging is present, when oedema is noted (in acute stage), circulation, sensation or pain impairment, thermoregulatory disorder and acute infection (Moreau 1993). The patient maintained normal daily activities and remained on medication if they were already on them, and refrained from medication if they were not on them.

On successful completion of the examinations, the patients were randomly placed into one of three groups, in order of acceptance, for example: the first person into the first group, the second into the second group, the third into the third group, the fourth into the first group, the fifth into the second, sixth into the third, and so. Treatment then commenced. The three groups were composed of the following; the first group consisted of 20 patients, all of whom received bilateral stretching of the upper trapezius muscle. The second group consisted of 20 patients, all of whom received bilateral stretching of the trapezius muscle in combination with heat application on the upper trapezius
musculature. The third group consisted of 20 patients, all of whom received bilateral stretching of the trapezius muscle in combination with cervical spinal adjustments.

3.1 Assessment of the patient.

A patient’s perception of pain or discomfort is not a good objective measure of spinal mobility or muscular imbalance. Similarly, removal of this sensation is not an objective measure of removing imbalances. By utilising an objective measure, such as the electrical activity in the back muscles, a perception independent measure of imbalance and subsequent change was reported (Shambaugh 1987). The rationale for using back muscles was that these structures might have been responsible for maintaining areas of hypomobility in the spine. Side-to-side imbalance in these muscles is presumed to indicate hypomobility or misalignment, and subsequent change in that activity provided an objective measurement. (Shambaugh 1987)

EMG readings were taken using a Synergy Plus EMG package from Clinical Solutions. EMG reading was a more accurate way to assess muscle tension. Hubbard and Berkoff (1993) had found sustained spontaneous electrical activity localised to the 1-2mm nidus of the latent TP’s. This activity was sustained for as long as they recorded, up to 50 minutes. There was also evidence that EMG readings may have been equivalent to subluxation determination (Shambaugh 1987). Shambaugh (1987) had found 85% agreement between EMG and neurological work-up, evidencing nerve root compromise. He also showed that changes in muscle electrical activity measured in distinct myotomes revealed nerve root disturbance.

Other studies have used a goniometer, which cannot isolate movements of a single muscle. The upper trapezius may not be the sole mover of the cervical spine, leading to the inability of the goniometer to accurately assess flexibility of the trapezius muscle.

Prior to the treatment the patients were seated with their backs against the wall, ensuring that head and shoulders were also against the wall. The surface area was cleaned with
alcohol swabs. One electrode was placed over the trapezius muscle on either side of the spine. The electrodes were placed midway between the spinous process of C7 and the acromion, at the angle of the neck. This position correlates closely with trigger point two of the trapezius muscle (Travell and Simons 1983). (See figure 2.7 p35 and figure 2.8 p36). A reading was taken for fifteen seconds. The treatment was then performed, following which the patient immediately assumed a position against the wall as described earlier. Another reading for fifteen seconds was taken.

This procedure was performed pre- and post-treatment, in all four visits and only EMG measurements at the follow-up consultation.

A subjective measurement was required to assess the patients response, therefore the Neck Pain and Disability Index (Vernon-Minor), which also includes a numerical pain rating scale 101 (Appendix E) was filled in prior to their first treatment and after their fourth and last treatment. The questionnaire not only assessed pain but also the functional ability of the patient.

Once the questionnaire was completed, each section scored zero (for statement one) to five (for statement six). Thus if all sections were completed, a maximum score of 50 was possible. If one section was left out, the total score possible was 45. The score obtained by the patient was then converted to a percentage to determine a disability rating (Meade et.al. 1990).

The method of measuring pain, using the numerical pain rating scale 101, gave the patient eleven possible boxes to select. The patient was informed to choose a value between zero and ten where zero denoted no pain and ten, severe pain. The appropriate block was then marked and these values were then plotted to give graphical representation of changes noted to facilitate discussion.
3.2 Treatment procedures. (Refer to table 3.1 p44)

3.2.1 The adjustment.

Many methods of chiropractic manipulation exist, but for the purposes of this research, only the diversified technique was utilised. Patients in this research were manipulated using various techniques, as set out in the diversified system, dependent on what was deemed most appropriate for the individual patient’s needs. Specific manipulation techniques were therefore not described, but basic principles for all the techniques were adhered to.

These basic principles were to firstly remove any joint slack from the joint to be adjusted (ie. the joint was taken to the elastic barrier of resistance). This was in effect a mobilization and all the adjustive techniques utilised could therefore be used as a mobilisation if a thrust was not employed. If manipulation was indicated, a high velocity, low amplitude, specifically directed thrust would have been performed once the elastic barrier was reached. (Haldeman 1992)

The spinal adjustments (high velocity, low amplitude) were delivered to the hypomobile cervical segments (C0-C7), especially the C2-C4 segments. The C2-C4 segments together with the spinal accessory nerve (cranial nerve XI) mainly supply the trapezius muscle (Travell and Simons 1983).

3.2.2 Muscle stretching.

Trapezius stretching: The patient sat in a chair and leant back comfortably, with the fingers hooked under the chair seat on each side, this lengthens the trapezius and stabilises the shoulders. To stretch the fibres, the operator side bends the patient’s head towards the opposite side (ear-to-shoulder). For maximum stretch the head was pressed forward to raise the occiput (Travell and Simons 1983). The stretch was held for a count to thirty seconds. This procedure was done three times.
3.2.3 Thermotherapy.

Heat packs were used for the thermotherapy. The heat packs were heated in the microwave (Goldstar for approximately two and one half of a minute) to about 102-110 degrees Fahrenheit (Reid 1992, Laban 1962, Lehmann et al. 1970, Mason and Rigby 1963). The heat packs were wrapped up in a moist paper towel and placed over the upper trapezius for 15 minutes (Reid 1992, Travell and Simons 1983).

3.3 Patient group procedures. (table 3.1)

All groups were thoroughly examined with an explanation on the initial visit, lasting no longer than 45 minutes. Treatment sessions thereafter lasted approximately 30 minutes. Each patient was expected to receive daily treatment for four days. According to Shambaugh (1987), the more frequent adjustments that were given, the greater the reduction in tension was observed. There was a follow-up one-week after the last treatment, in order to determine if the treatment effects were maintained.

Group 1: After completion of the paper work, and EMG readings, the patients were adjusted at the specific hypomobile fixations, followed by stretching of the TM bilaterally. Immediately post-treatment, EMG readings were recorded. This procedure was repeated on all treatment days for this group.

Group 2: After completion of the paper work, and EMG readings, the patients received the heat pack therapy for 15 minutes on both muscles, followed by stretching of the TM bilaterally. Immediately post-treatment, EMG readings were recorded. This procedure was repeated on all treatment days for this group.

Group 3: After completion of the paper work, and EMG readings, the patients received stretching of the trapezius bilaterally only. Immediately post-treatment, EMG readings were recorded. This procedure was repeated on all treatment days for this group.
<table>
<thead>
<tr>
<th></th>
<th>Group one</th>
<th>Group two</th>
<th>Group three</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examination: initial visit</td>
<td>Questionnaire, EMG, Physical and regional examination</td>
<td>Questionnaire, EMG, Physical and regional examination</td>
<td>Questionnaire, EMG, Physical and regional examination</td>
</tr>
<tr>
<td>Examination: follow-up treatments.</td>
<td>‘soap’ notes</td>
<td>‘soap’ notes</td>
<td>‘soap’ notes</td>
</tr>
<tr>
<td>Examination: follow-up assessment.</td>
<td>Questionnaire and EMG</td>
<td>Questionnaire and EMG</td>
<td>Questionnaire and EMG</td>
</tr>
<tr>
<td>Time allowed for initial visit</td>
<td>45 minutes</td>
<td>45 minutes</td>
<td>45 minutes</td>
</tr>
<tr>
<td>Time allowed for follow-up</td>
<td>25 minutes</td>
<td>30 minutes</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Number of treatment days.</td>
<td>4 consecutive</td>
<td>4 consecutive</td>
<td>4 consecutive</td>
</tr>
<tr>
<td>Assessment procedures.</td>
<td>Questionnaire and EMG</td>
<td>Questionnaire and EMG</td>
<td>Questionnaire and EMG</td>
</tr>
</tbody>
</table>

Table 3.1: The above table summarises the treatment procedures.

Statistical analysis of the data was done by the Kruskall-Wallis test (non-parametric), by comparing the follow-up readings to the initial readings (Boyd, 1999). The intermediate readings were compared graphically and statistically. Where desired, readings after the fourth treatment were compared with the initial readings by minusing the first reading from the fourth in the Kruskall-Wallis method. This method allows one to compare three or more groups simultaneously. To identify a specific treatment time within the Kruskall-Wallis method the following two methods were used, the Students-Newman-Keuls method and the Dunn’s method. Where only two groups were compared the Mann-Whitney Rank Sum Test was used for better comparison (Boyd, personal communication 1999).
CHAPTER FOUR

RESULTS

4.1 Summation.

The results obtained from the measurable variables (EMG recordings) were tabulated and analysed. Each of the three groups, viz. the adjustment group, the heat group and the stretch group, had measurements taken with regard to trapezius muscle tension, using an EMG. These measurements constituted objective measurements and were obtained before treatment began and after treatment ended on each visit. Subjective measurements were obtained before the initial treatment and on the follow-up, by having the patient complete the Vernon-Mior neck disability index and the numerical pain rating scale questionnaire.

The statistically analysed mean of the data were used to plot bar and line graphs indicating the objective changes in EMG recordings over the four treatment sessions and the one week follow-up for the trapezius musculature. Graphs were also plotted indicating the respective subjective changes in patients' functional ability and pain intensity rating responses as measured by the Vernon-Mior neck disability index and the numerical pain rating scale, respectively.
4.2 Demographics.

<table>
<thead>
<tr>
<th></th>
<th>Adjustment</th>
<th>Heat</th>
<th>Stretching</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Age</strong></td>
<td>31.4</td>
<td>47.5</td>
<td>45.8</td>
<td>41.6</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>45%</td>
<td>50%</td>
<td>100%</td>
<td>65%</td>
</tr>
<tr>
<td>Female</td>
<td>55%</td>
<td>50%</td>
<td>0%</td>
<td>35%</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>85%</td>
<td>10%</td>
<td>0%</td>
<td>31.7%</td>
</tr>
<tr>
<td>Black</td>
<td>10%</td>
<td>75%</td>
<td>95%</td>
<td>60%</td>
</tr>
<tr>
<td>Indian</td>
<td>5%</td>
<td>15%</td>
<td>5%</td>
<td>8.3%</td>
</tr>
<tr>
<td><strong>Number of Patients</strong></td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td><strong>Number of Dropouts During the Treatments</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Number of Dropouts During the Follow-up</strong></td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 4.1: A comparison of the three treatment groups with respect to age, sex, race, number of patients, and dropouts, as noted in the case history.
4.3 Results from the Questionnaire.

Graph 4.1: This graph graphically compares the percentile values of the questionnaires. Zero percent denotes zero disability. It compares the difference between the pre-treatment and the follow-up values of each group and among the group.

In the stretching group the differences in the median values among the two groups were not great enough to exclude the possibility that the difference was due to a random sampling variability; there was not a statistically significant difference (p=0.102), using the Mann-Whitney Rank Sum Test.

In the heat group the differences in the median values among the two groups were not great enough to exclude the possibility that the difference was due to a random sampling variability; there was not a statistically significant difference (p=0.366), using the Mann-Whitney Rank Sum Test.
In the adjustment group the differences in the median values among the two groups were not great enough to exclude the possibility that the difference is due to a random sampling variability; there was not a statistically significant difference (p=0.273), using the Mann-Whitney Rank Sum Test.

Graphically one can clearly see a decrease in value from the pre-treatment to the post-treatment in all three groups. However, the decrease was not statistically different in each case. One can also visualise in the adjustment group that there was a bigger difference between the pre- and post-treatments, as comparing it to the smaller differences in the heat and stretch groups, thus although not statistically significant, perhaps a longer treatment period may have proved the adjustment group to be significant.
4.4 Results from the Pain rating index.

Graph 4.2: This graph represents the percentile values (x10) for the pain rating index. Zero denotes no pain. The graph shows the difference between the pre-treatment and the follow-up of each group and among each group.

In the stretching group the differences in the median values among the two groups were not great enough to exclude the possibility that the difference was due to a random sampling variability; there was not a statistically significant difference (p=0.102), using the Mann-Whitney Rank Sum Test.

In the heat group the differences in the median values among the two groups were not great enough to exclude the possibility that the difference was due to a random sampling variability; there was not a statistically significant difference (p=0.398), using the Mann-Whitney Rank Sum Test.
In the adjustment group the differences in the median values among the two groups were greater than would be expected by chance and there was a statistically significant difference ($p=0.0231$), using the Mann-Whitney Rank Sum Test.

Although it was graphically visible that there was a decrease in pain in all three groups, when comparing the initial pre-treatment to the follow-up final treatment, only the adjustment group was significantly different. It was also visible that the biggest decrease in value between pre- and post- treatment was the adjustment group, almost by 50%.

4.5 Results from the adjustment group.

Graph 4.3: This bar graph represents the values in millivolts, as recorded by an EMG, for the four pre- and post- adjustment treatments, and the follow-up recording.

One can observe that there was a decrease in EMG recording (tension) after each treatment. The pre-treatment EMG recording for each day was lower than the previous
days. This may indicate that the adjustment decreases tension post treatment, as well as maintaining it.

In the adjustment group, comparing the follow-up to the fourth pre-treatments and to the initial pre-treatments, the differences in the median values among the treatment days are not great enough to exclude the possibility that the differences were due to random sampling variability; there was not a statistically significant difference (p=0.430), using the Kruskal-Wallis One Way Analysis of Variance on Ranks.

In the adjustment group, comparing the follow-up to the fourth post-treatments and to the initial pre-treatments, the differences in the median values among the treatment groups are not great enough to exclude the possibility that the differences was due to random sampling variability; there was not a statistically significant difference (p=0.255), using the Kruskal-Wallis One Way Analysis of Variance on Ranks.
4.6 Results from the heat group.

Graph 4.4: This bar graph represents the pre- and post- EMG heat treatment recordings, in all four days as well as the follow-up recording.

In the heat group, comparing the follow-up to the fourth pre-treatments and to the initial pre-treatments, the differences in the median values among the treatment groups are not great enough to exclude the possibility that the differences was due to random sampling variability; there is not a statistically significant difference (p=0.864), using the Kruskal-Wallis One Way Analysis of Variance on Ranks.

One can observe that there was a decrease in tension after each treatment. The pre-treatment tension recordings for each day are much lower than the initial recordings. The post-treatment values seem to de-escalate with every treatment.
4.7 Results from the stretching group.

**Graph 4.5:** This bar graph represents the pre- and post- EMG treatment recordings in the stretching group. It represents the four treatment days and the follow-up recording.

In the stretching group, comparing the follow-up to the fourth pre-treatments and to the initial pre-treatments on the left side, the differences in the median values among the treatment days are greater than would be expected by chance; there was a statistically significant difference (p=0.0330), using the Kruskal-Wallis One Way Analysis of Variance on Ranks.

To identify the treatment day that differed from the other a Student-Newman-Keuls Method was used: In comparing the fourth pre-treatment to the follow-up on the left side there was a statistically significant difference. In comparing the first pre-treatment to the follow-up on the left, there was a statistically significant difference. In comparing the first pre-treatment to the fourth pre-treatment on the left, there was no statistically significant difference.
In the stretching group, comparing the follow-up to the fourth pre-treatments and to the initial pre-treatments on the right side, the differences in the median values among the treatment groups are greater than would be expected by chance; there was a statistically significant difference (p=0.00660), using the Kruskal-Wallis One Way Analysis of Variance on Ranks.

To identify the stretching treatment day that differed from the other days the Dunn's Method was used: In comparing the fourth pre-treatment to the follow-up on the right side there was a statistically significant difference. In comparing the first pre-treatment to the follow-up on the right, there was no statistically significant difference. In comparing the first pre-treatment to the fourth pre-treatment on the right, there was no statistically significant difference.
4.8 Graphical results comparing the three groups.

4.8.1 Combined pre-treatment right side.

Graph 4.6: This bar graph compares the right side pre-treatment EMG recordings among the three groups in the four treatment days.

On the right side one notices a considerably higher trapezius muscle EMG recordings in the adjustment group as compared to the heat and stretching group. This may be due to the race, sex or even their occupation.

The heat group pre-treatment tension has decreased and stabilised. The stretch group was not affected.
4.8.2 Combined post-treatment on right side.

Graph 4.7: This bar graph represents the right side post-treatment EMG recordings among the three groups in the four treatment days and on the follow-up day.

The adjustment group EMG recordings have decreased considerably, whereas the other two groups EMG recordings were decreased slightly. The heat and stretch groups were very much similar, which made it difficult to differentiate which modality was responsible for the change.
Graph 4.8: This bar graph compares the left side pre-treatment EMG recordings among the three groups in the four treatment days. The left side tension was more regular and more representative of the three groups. One observes the gradual decrease in tension from treatment to treatment, especially in the adjustment group. The tension on the left side was considerably lower than the right side, especially referring to the adjustment group. It was interesting to note that the majority of the patients in this study had a higher EMG recording on the right side, and the majority being right handed.
Graph 4.9: This bar graph represents the left side post-treatment EMG recordings among the three groups in the four treatment days and on the follow-up day.

In comparing the post-treatment one observes the decreased tension in all three groups. There was no real pattern developing, except for the heat group. The adjustment group decreased the most as compared to the other two groups, but the change was not as dramatic as the right side.

4.9 Graphical representation of spinal fixations.

All patients were found to have hypomobile segments. During the screening process for the adjustment group, the patience that did not have hypomobile segments were excluded from the study. The fixations found by the examiner were classed as primary and secondary. The primary felt more fixated than the secondary, and was also painful to digital pressure. The primary fixations were adjusted first, until they cleared up, thereafter moving to the secondary non painful fixations.
4.9.1 Cervical spinal fixations for the adjustment group.

Graph 4.10: Bar graph representing the number of fixations found in the adjustment group at certain cervical levels corresponding to the main innervation area of the trapezius musculature.

Unfortunately there was no motion palpation in the follow-up session, and therefore these fixations are represented from the initial consultation and on the treatment days. This eliminates any comparison of pre-adjustment and post-treatment.

It was noticeable that most of the fixations were found between the C1-C2 to C4-C5 vertebral motion segments. These segments closely correlated to the innervation level of the trapezius muscle. (Travell and Simons 1983)

One notices that the right side of the cervical region had more primary fixations than the left side, between the C1 and C4 vertebrae. One also notices that the right side had more secondary fixations than the left cervical spine, when comparing between the C1 to C4
vertebrae. This finding correlated with the higher muscle tension recorded on the right trapezius muscle, especially in the adjustment group.

4.9.2 Cervical spine fixations for the heat and stretching groups combined.

Graph 4.11: Bar graph representing the number of cervical segment fixations found in the heat and stretching groups. Note the cervical segments which correspond to the main innervation area of the trapezius musculature.

The heat and stretching groups were grouped together because motion palpation was not accurately performed, owing to the fact that these patients were not adjusted. It was noted that there was a wider spread of fixations, as compared to the adjustment group. There were more fixations at the C0-C1, C7-T1 spinal motion segments. There were clearly a larger number of primary and secondary fixations on the right side of the cervical spine. This correlated with higher EMG recordings on the right side. It was interesting that most subjects were right handed.
CHAPTER FIVE

DISCUSSION.

5.1 Summation.
Forty-nine patients attended the follow-up week assessment. Many patients without revealing any reasons, could not make it. Owing to the small sample size, this study may therefore be regarded as a pilot study.

5.2 Sub-problem one.
The first sub-problem was to evaluate the effectiveness of cervical spine adjustment in combination with stretching of the upper trapezius musculature in the treatment of hypertonic trapezius musculature.

5.2.1 Objective findings.
The adjustment group received adjustments to the hypomobile cervical segments followed by stretching of the trapezius muscles bilaterally. EMG recordings failed to show any statistically significant difference between the pre-initial treatment and the follow-up (P=0.430), using the Kruskall-Wallis One Way Analysis of Variance on Ranks. However, the graph 4.3 shows a decreasing trend between the initial treatment and the follow-up.

5.2.2 Subjective findings.
5.2.2.1 Questionnaire
There was no statistically significant difference between the pre-initial treatment and the follow-up (p=0.273). However, the graph 4.1 shows a decrease in value from the initial pre-treatment to the follow-up.

5.2.2.2 Pain rating scale
There was no statistically significant difference between the pre-initial treatment and the follow-up (p=0.151). The graph 4.2 does however show a decrease in value from the initial pre-treatment (average 1.75) to the follow-up (0.9).
5.2.3 Discussion.

The above results do not corroborate with the findings of Herzog (1999) who concluded that spinal treatments had been associated with measurable EMG responses in inhibiting hypertonic muscles, reducing pain and increasing functional ability.

The graphs 4.1, 4.2, and 4.3 with their observable trends are the only evidence in this study to support Herzog’s hypothesis.

In the present study there was a minute or two delay after the delivery of the adjustment, due to the stretching, which may not confirm the findings of Herzog and others, who’s findings indicate that there is no active recruitment of muscles after SMT. The time of onset of the electromyographic response after SMT (as short as 50 m/sec) is too short for an active process; therefore, it is highly likely that the observed responses were of a reflexive nature (Herzog 1999, Fuhr 1986, Triano 1992), although an observation by the examiner was made that straight after the adjustment and prior to stretching the EMG recordings were lower than the recordings after stretching. The stretching may have activated a recruitment of muscle action, because according to Alter (1988) stretching a muscle lengthens both muscle fibre and muscle spindle. The consequent deformation within the muscle spindle results in the firing of the stretch reflex, which contracts the muscle. Muscle has the ability to store energy in its elastic components and then release that energy. This stored energy may have been responsible for the raise in EMG recordings soon after the stretch. The results may have altered if the stretch was held for a longer period of time, and the readings taken a minute or two after stretching.

Herzog (1999) made observations in symptomatic patients who had local muscular hypertonicities that were largely abolished immediately after the SMT-induced EMG response, therefore supporting the idea that SMT reduces hyperactivation of muscles in areas of back pain. Hubbard and Berkoff (1993) postulated that the adjustment affects the sympathetic nervous system, and this indirectly affects the general well being of patients. These two studies support the statistically significant difference found in the Pain rating index of the adjustment group (graph 4.2 pg.49).
5.3 Sub-problem two.
The second sub-problem was to evaluate the effectiveness of thermotherapy in combination with stretching of the upper trapezius musculature in the treatment of hypertonic trapezius musculature.

5.3.1 Objective findings.
The heat group received heat in the form of heat packs to the upper trapezius musculature bilaterally for 15 minutes. EMG recordings failed to show any statistically significant difference between the pre-initial treatment and the follow-up (p=0.864), using the Kruskall-Wallis One Way Analysis of Variance on Ranks. However, the graph 4.4 shows a decrease in EMG recording after every treatment.

5.3.2 Subjective findings.
5.3.2.1 Questionnaire.
There was no statistically significant difference between the pre-initial treatment and the follow-up (p=0.273), using the Mann-Whitney Rank Sum Test. The average for the pre-treatment (12.7) however, was higher than the follow-up average (11.35). The graph 4.1 shows a decrease in value from the initial pre-treatment to the follow-up.

5.3.2.2 Pain rating scale.
There was no statistically significant difference between the pre-initial treatment and the follow-up (p=0.314). The graph 4.2 shows a decrease in value from the initial pre-treatment (average 1.66) to the follow-up (1.05).

5.3.3 Discussion.
The above results do not support the findings of Foster (1985) and Travell and Simons (1983), who both stated that heat tends to relax the underlying muscles, diminish the tension on the TP’s and increase efficiency of muscle action. However, the graph 4.4 with its observable EMG recordings may endorse Foster and Travell and Simons in their findings.
5.4 Sub-problem three
The third sub-problem was to evaluate the effectiveness of stretching of the upper trapezius musculature in the treatment of hypertonic trapezius musculature.

5.4.1 Objective findings.
In this group the subjects received static stretch for a count of thirty seconds bilaterally, and a difference in the median values among the treatment groups were greater than would be expected by chance; therefore there was a statistically significant difference (P = 0.0330), using the Kruskal-Wallis One Way Analysis of Variance on Ranks.

To isolate the treatment day that differed from the others a multiple comparison procedure was used (Student-Newman-Keuls Method): In comparing the fourth pre-treatment to the follow-up on the left side there was a statistically significant difference. In comparing the first pre-treatment to the follow-up on the left, there was a statistically significant difference. In comparing the first pre-treatment to the fourth pre-treatment on the left, there was no statistically significant difference. Similar results were found for the right side.

5.4.2 Subjective findings.
5.4.2.1 Questionnaire.
In the stretching group the differences in the median values among the two groups were not great enough to exclude the possibility that the difference was due to a random sampling variability; there was not a statistically significant difference (p=0.102), using the Mann-Whitney Rank Sum Test.

5.4.2.2 Pain rating scale.
In the stretching group the differences in the median values among the two groups were not great enough to exclude the possibility that the difference was due to a random sampling variability; there was not a statistically significant difference (p=0.102), using the Mann-Whitney Rank Sum Test.
5.4.3 Discussion
The above results support deVries and Adams (1972) who found exercise to be more effective than medication in decreasing muscular tension. They also support EMG recordings by deVries (1966) who had showed that static stretching relieves muscle soreness and significantly decreases electrical activity in the muscle bringing symptomatic relief. Although the subjective findings do not correlate with Alter’s (1998) experience and research that slow stretching can reduce and sometimes eliminate muscle soreness, Graphs 4.1 and 4.2 show otherwise.

Muscles usually operate in pairs so that when one muscle, the agonist, contracts, the opposing antagonist muscles relaxes. This is reciprocal innervation, and may come into play as the stretch reflex is initiated. This helps to relax the muscle further producing the present results. The golgi tendon organ function as an inhibitory mechanism, thereby, facilitating muscle relaxation when stimulated by the stretch. (Alter 1988 and Guyton 1991)

5.5 Sub-problem four.
The fourth sub-problem was to compare the results within each group and between the three groups in order to determine whether there were any significant differences in therapeutic potential.

5.5.1 Objective findings.
In both the adjustment and the heat groups the EMG recordings show no statistically significant difference, thereby favouring neither treatment, in therapeutic potential. Stretching on the other hand received a favourable statistical outcome, making stretching the treatment of choice.

5.5.2 Subjective findings.
There was no statistically significant difference among the heat, the adjustment and the stretch groups with regards to pre-treatment and the follow-up questionnaires. There was no statistically significant difference among the heat, the adjustment and the stretch groups with regards to pre-treatment and the follow-up pain rating index scale.
5.5.3 Discussion.

These findings disprove the hypothesis that thermotherapy in combination with stretching of the trapezius musculature would be more beneficial than SMT of the cervical spine in combination with stretching of the trapezius musculature.

However, both the heat group and the adjustment groups graphically presented with favourable results within each treatment day. Graphs 4.3 and 4.4 graphically show that there was a decrease in post-treatment EMG recording on each day, for all four days. It is graphically also visible that the EMG recordings prior to the treatment on the second to fourth days was lower than the initial pre-treatment EMG recordings. These observations corroborate with the clinical and anecdotal observations of EMG responses associated with SMT that have been made for a long time (Herzog 1999).

The EMG readings were taken shortly (10 to 20 seconds to replace the electrodes) after the stretch revealing statistically significant results. If the EMG readings were taken a minute or two after the stretch, the readings may, possibly, have been lower. The possible delay in EMG recording may give the muscle spindle time to adapt to the new length, thereby decreasing muscle tension.

The graphical results from the pain index (graph 4.2) show clearly that there was a decrease in the scale post treatment in the groups. Similarly there was a decrease in post treatment value for the questionnaires (graph 4.1) in all three groups.

In comparing graph 4.6 to graph 4.7 it is visible that there was a greater decrease in the right side millivolt recordings for the adjustment group than for the heat and the stretching group. In comparing the left side millivolt recordings, using graph 4.8 and 4.9 similar results are observed.

Studying graph 4.10 and 4.11 it was interesting to note that most fixations were found between the C1-C2 to C4-C5 vertebral motion segments for the adjustment group which closely correlates to the innervation level of the trapezius musculature viz. C2-C4. In the
heat and stretching group most fixations were found between the C0-C1 and C7-T1
vertebral motion segments. In both graphs there was a higher number of primary and
secondary fixations on the right side of the cervical spine, which correlates with the
higher EMG recordings on the right side (graph 4.6-4.9). It was intriguing to find most
subjects were right handed.

In conclusion, there is moderate evidence that SMT is more effective than thermotherapy
in the treatment of hypertonic musculature.
CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions.

The present findings lead to the conclusion that thermotherapy in combination with stretching of the trapezius musculature would not be more beneficial than SMT of the cervical spine in combination with stretching of trapezius musculature.

SMT may appear to contribute more than thermotherapy, both objectively and subjectively. The mere fact that the adjustment group showed improvements in the EMG recordings in comparison to the heat group, is an indication that SMT of the cervical spine in the treatment of hypertonic musculature may be useful. To obtain statistical significance however, a larger sample size may be required as well as a longer treatment period.

6.2 Recommendations.

It is recommended that in order for this study to be effectively comparative, a substantially larger sample group will be required. Due to the sample group ie. 20 patients in each group, statistical results may not have been representative of the population as a whole, therefore no assumption could be made with relevance to the population.

This demonstration, that objective physiological changes can be observed, suggests more study is needed. This study does not answer several questions, such as what happens on a long term basis, or whether we are seeing a placebo effect (just placing hands on the subject).

Unfortunately there was no motion palpation on the follow-up, which eliminates any comparison from the initial treatment. A recommendation to motion palpate throughout the research, especially in the heat and stretch groups, will provide more information on the spinal motion units for comparative purposes.
Paraspinal musculature is electromyographically silent in normal subjects at rest (Haldeman 1992). All the subjects had active electromyographic readings at rest on the initial treatment days. That was most likely due to the trapezius muscle constantly working to keep the shoulder girdle in its position against gravity. If, perhaps, the subjects were lying supine the electromyographic readings would have been silent, and a better base line would be achieved.

Spinal manipulative treatments performed on the left and right side of the spine may not have been similar in extent and magnitude. This may have some influence on the asymmetrically evoked EMG responses for the cervical treatments. It was concluded that it was probably caused by adominance or asymmetry in adjusting the left side of the spine by the practitioner, or by the observation that most subjects were dominant on the right side.

It may be useful to adopt the normalisation of data procedure described by Lehman and McGill (1999). This EMG normalisation is the process by which the millivolts of activity are expressed as a percentage of that muscle’s activity during a calibrated test contraction. According to Lehman and McGill (1999) the EMG is highly variable and is dependent upon electrode application and placement, perspiration and temperature, muscle fatigue, contraction velocity and muscle length, cross talk from nearby muscles, activity in other synergists and antagonists, subcutaneous fat thickness, and slight variation in task execution, to name a few. It would be impossible to control all of these modulators of EMG amplitude in a clinical setting. Normalisation controls for the aforementioned variables and facilitates the comparison of EMG signals across muscles, between subjects, or between days within a subject.

In the present study, an unplanned observation was that the EMG recording had decreased post adjustment, and started to increase during and post stretching of the same subject. It was also noted that a reading a minute or two after stretching showed a lower EMG recording than the reading straight after the stretch. It is therefore my recommendation that there should be no stretching after any treatment modalities, and that there should be a fourth, placebo group to facilitate comparisons and to isolate the treatment modality of choice.
The sexes were not evenly distributed and this may have altered the EMG recordings as the male skeletal structure may be slightly different. It is recommended to have an equal number, or to have one kind of sex. The race was not evenly distributed nor was the age group. Eliminating any of these variables may result in more accurate results, but may not represent the population as a whole.
REFERENCES


APPENDICES

APPENDIX A

Patient consent form

Date:

I, the undersigned, ____________________________, give my informed consent to be examined and treated by the chiropractic intern, and will comply with the instructions as stipulated by the intern with regards to his research project.

The undersigned, has the right to terminate their participation in this project, without revealing any reasons. The intern must be notified, however.

signature
APPENDIX B

TECHNIKON WITWATERSRAND
CHIROPRACTIC DAY CLINIC

CASE HISTORY

Date: ____________________

Patient: ____________________  File No: ____________________

Age: _______  Sex: _______  Occupation: ____________________

Intern: ____________________  Signature: ____________________

FOR CLINICIAN'S USE ONLY

Initial visit clinician: ____________________  Signature: ____________________

Case History:

__________________________________________________________________________

Examination:

Previous: TWR  Other  Current: TWR  Other

X-ray Studies:

Previous: TWR  Other  Current: TWR  Other

Clinical pathology:

Previous: TWR  Other  Current: TWR  Other

Case status:

P.T.T: Conditional  Signed off: Final sign out: ____________________

Recommendations:

__________________________________________________________________________
Intern's 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 & 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
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
Nose/sinuses
Mouth/throat
Neck
Breasts
Respiratory
Cardiac
Gastro-intestinal
Urinary
Genital
Vascular
Musculoskeletal
Neurologic
Haematologic
Endocrine
Psychiatric
TECHNIKON WITWATERSRAND
CHIROPRACTIC DAY CLINIC

PHYSICAL EXAMINATION

Underline abnormal findings in RED: Date: __________

Patient: __________________________ File No: __________

Clinician: __________________________ Signature: __________

Intern: __________________________ Signature: __________

Height: __________ Weight: __________ Temp: __________

Rates: Heart: __________ Pulse: __________ Respiration: __________

Blood pressure: Arms: L R

Llegs: L R

General Appearance:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
STANDING EXAMINATION

1. Minor's sign
2. Skin changes
3. Posture: Erect

Adams's

4. Ranges of motion (Thoracolumbar Spine)
   - T-L spine: Flexion: 90° (fingers to floor)
   - Extension: 50°
   - R lat flex: 30° (fingers down leg)
   - L lat flex: 30° (fingers down leg)
   - Rot to R: 35°
   - Rot to L: 35°

5. Romberg's sign
6. Pronator drift
7. Trendelenburg's sign
8. Gait:
   - rhythm
   - balance
   - pendulousness
   - on toes
   - on heels
   - tandem

9. Half squat
10. Scapular winging
11. Muscle tone
12. Spasticity/Rigidity

/ = pain-free limitation // = painful limitation
13. Shoulder
- skin
- symmetry
- ROM:
  - glenohumeral
  - scapulo-thoracic
  - acromioclavicular
  - elbow
  - wrist

14. Chest measurement:
- inspiration
- expiration

15. Visual acuity

16. Breast examination
- Inspection
  - skin
  - size
  - contour
  - ripples
  - arms overhead
  - hands against hips
  - leaning forward
- Palpation
  - axillary lymph nodes
  - breast incl. tail

SEATED EXAMINATION

1. Spinal posture
2. Head:
  - hair
  - scalp
  - skull
  - face
  - skin
3. Eyes:
   - Observation
     - conjunctiva
     - sclera
     - eyebrows
     - eyelids
     - lacrimal glands
     - nasolacrimal duct
     - position and alignment
     - corneas and lenses
   - corneal reflex
   - ocular movement
     L
     \[ \text{III IV VI} \]
     R
     \[ \text{III IV VI} \]
visual fields
accommodation
Optophthalmoscopic
Examination
- iris
- pupils
- red reflex
- optic disc
- vessels
- general background
- macula
- vitreous
- lens

4 Ears
- Inspection
  - auricle
  - ear canal
  - drum

  - auditory acuity
  - Weber test
  - Rinne test

5 Nose
- external
- internal
  - septum
  - turbinates
  - olfaction

6 Sinuses (frontal & maxillary)
  - tenderness
  - transillumination

7 Mouth and pharynx:
- lips
- buccal mucosa
- gums and teeth
- roof
- tongue
  - inspection
  - movement
  - taste
  - palpation

- pharynx
  - inspection
  - CN X
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**SUPINE EXAMINATION**

1. JVP
2. PMI
3. Auscultation heart
   (L.it recumbent)
4. Respiratory excursion
5. Percussion chest
   (anterior)
6. Breast palpation
7. Abdominal Examination
   * Inspection:
     - skin
     - umbilicus
     - contour
     - peristalsis
     - pulsations
     - hema (umbilical/incisional)
   * Auscultation:
     - bowel sounds
     - bruit
   * Percussion:
     - general
     - liver
     - spleen
   * Palpation:
     - superficial reflexes
     - cough
     - light
     - rebound tenderness
     - deep
     - liver
     - spleen
     - kidneys
     - aorta
     - infra-hiato abdominal wall mass
     - splenic dulness
     - flank wave
   * Acute abdomen:
     - where pain began and now
     - cough
     - tenderness
     - guarding/irritability
     - rebound tenderness
     - Reussing's sign
     - psoas sign
     - Bellingham sign
     - rectal bleed
     - Murphy's sign
   * Male genitale and hema
     * Inspection:
       - skin
       - pressure
       - glans
       - meatus
       - meata
1. Perineal:
- scrotum
- inguinal/femoral bulges

2. Palpation:
- penis (tenderness/induration)
- testes
- epididymis
- inguinal canal
- femoral canal
- cremasteric reflex

3. Auscultation:
- scrotal mass

4. Peripheral vasculature:

5. Inspection:
- skin
- nail beds
- pigmentation
- hair loss

6. Palpation:
- pulses: femoral, popliteal, radial, post-tibial, brachial
- lymph nodes: epitrochlear, femoral (horizontal and vertical)
- temperature (feet and legs)

7. Manual compression test
8. Retrograde filling (Trendelenburg) test
9. Arterial insufficiency test

10. Musculoskeletal:
   1. ROM:
      i. Hip:
         | flex | 90/120 |
         | ext  | 15     |
         | abd  | 45     |
         | add  | 30     |
         | int rot | 40 |
         | ext rot | 45 |
         | L     | R      |
- **knee**

- **ankle**

  (n) leg length

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12. Rectal examination:
- Inspection: sacroccygeal & perineal areas
- Palpation: sphincter tone, tenderness, induration, nodules, prostate, seminal vesicles

MENTAL STATUS
(i) Appearance and behaviour
- level of consciousness
- posture and motor behaviour
- dress, grooming, personal hygiene
- facial expression
- affect

(ii) Speech and language
- quantity
- rate
- volume
- fluency
- aphasia (jmr)

(iii) Mood

(iv) Thought processes (logical, relevant, organised)

(v) Memory and attention
- orientation (time, place, person)
- recent memory
- new learning ability

(vi) Higher cognitive functions
- information and vocabulary (general & specialised knowledge)
- abstract thinking
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</table>

**Neurological Examination**

- Left: Normal
- Right: Normal

**Motor Examination**

- Left: Normal
- Right: Normal
APENDIX D

TECHNIKON WITWATERSRAND
CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION
CERVICAL SPINE

Patient: ___________________________
Clinician: __________________________
Intern: __________________________

Date: __________________________
File No.: __________________________
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. Lateral flexion: = 20° - 45°
**PALPATION**

- Lymph nodes
- Trachea
- Thyroid gland
- Pulses / thrills
- Tenderness
- Muscle Tone
**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 Maneuver
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

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### COMMENTS


### MOTION PALPATION

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### APPENDIX E

**Neck Pain and Disability Index (Vernon-Morris)**

Patient Name: ___________________  File #: ___________________  Date: ___________________

Please read instructions:

This questionnaire has been designed to give the doctor information as to how your neck pain has affected your ability to manage in everyday life. Please answer every section and mark in each section only the ONE box which applies to you. We realize you may consider that two of the statements in any one section relate to you, but just mark the box which most closely describes your problem.

<table>
<thead>
<tr>
<th>SECTION 1 - PAIN INTENSITY</th>
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<tbody>
<tr>
<td>□ I have no pain at the moment.</td>
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<tr>
<td>□ The pain is very mild at the moment.</td>
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<tr>
<td>□ The pain is moderate at the moment.</td>
</tr>
<tr>
<td>□ The pain is fairly severe at the moment.</td>
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<tr>
<td>□ The pain is the worst imaginable at the moment.</td>
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<thead>
<tr>
<th>SECTION 2 - PERSONAL CARE (Washing, Dressing, etc.)</th>
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<tbody>
<tr>
<td>□ I can look after myself normally without causing extra pain.</td>
</tr>
<tr>
<td>□ I can look after myself normally but it causes extra pain.</td>
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<tr>
<td>□ It is painful to look after myself and I am slow and careful.</td>
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<tr>
<td>□ I need some help but manage most of my personal care.</td>
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<tr>
<td>□ I need help every day in most aspects of self care.</td>
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<tr>
<td>□ I do not get dressed, wash with difficulty and stay in bed.</td>
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<th>SECTION 3 - LIFTING</th>
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<td>□ I can lift heavy weights without extra pain.</td>
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<tr>
<td>□ I can lift heavy weights but it gives extra pain.</td>
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<tr>
<td>□ I can lift light weights if I am well rested, but I cannot manage to lift light weights if I am tired.</td>
</tr>
<tr>
<td>□ I cannot lift light weights.</td>
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<th>SECTION 4 - READING</th>
</tr>
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<tbody>
<tr>
<td>□ I can read as much as I want to with no pain in my neck.</td>
</tr>
<tr>
<td>□ I can read as much as I want to with slight pain in my neck.</td>
</tr>
<tr>
<td>□ I can read as much as I want to with moderate pain in my neck.</td>
</tr>
<tr>
<td>□ I cannot read as much as I want to because of moderate pain in my neck.</td>
</tr>
<tr>
<td>□ I can hardly read at all because of severe pain in my neck.</td>
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<tr>
<td>□ I cannot read at all.</td>
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</table>

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<thead>
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<th>SECTION 5 - HEADACHES</th>
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<tbody>
<tr>
<td>□ I have no headaches at all.</td>
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<tr>
<td>□ I have slight headaches which come infrequently.</td>
</tr>
<tr>
<td>□ I have moderate headaches which come occasionally.</td>
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<tr>
<td>□ I have severe headaches which come frequently.</td>
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<td>□ I have headaches almost all the time.</td>
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<th>SECTION 6 - CONCENTRATION</th>
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<tr>
<td>□ I can concentrate fully when I want to with no difficulty.</td>
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<tr>
<td>□ I can concentrate fully when I want to with slight difficulty.</td>
</tr>
<tr>
<td>□ I can concentrate fully when I want to with moderate difficulty.</td>
</tr>
<tr>
<td>□ I can concentrate fully when I want to with great difficulty.</td>
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<tr>
<td>□ I cannot concentrate at all.</td>
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<th>SECTION 7 - WORK</th>
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<td>□ I can do as much work as I want to.</td>
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<tr>
<td>□ I can only do as much work as I want to.</td>
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<tr>
<td>□ I cannot do all of my usual work.</td>
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<tr>
<td>□ I cannot do my usual work.</td>
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<tr>
<td>□ I cannot do any work at all.</td>
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<tr>
<th>SECTION 8 - DRIVING</th>
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<tbody>
<tr>
<td>□ I can drive my car without neck pain.</td>
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<tr>
<td>□ I can drive my car as long as I want with slight pain in my neck.</td>
</tr>
<tr>
<td>□ I can drive my car as long as I want with moderate pain in my neck.</td>
</tr>
<tr>
<td>□ I cannot drive my car as long as I want because of moderate pain in my neck.</td>
</tr>
<tr>
<td>□ I cannot drive my car at all because of severe pain in my neck.</td>
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<tr>
<td>□ I cannot drive my car at all.</td>
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<thead>
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<th>SECTION 9 - SLEEPING</th>
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<tbody>
<tr>
<td>□ I have no trouble sleeping.</td>
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<tr>
<td>□ My sleep is mildly disturbed (less than 1 hr sleep loss).</td>
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<tr>
<td>□ My sleep is moderately disturbed (2-3 hrs sleep loss).</td>
</tr>
<tr>
<td>□ My sleep is greatly disturbed (4-6 hrs sleep loss).</td>
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<tr>
<td>□ My sleep is completely disturbed (6-7 hrs sleep loss).</td>
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<thead>
<tr>
<th>SECTION 10 - RECREATION</th>
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<tbody>
<tr>
<td>□ I am able to engage in all my recreation activities with neck pain at all.</td>
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<tr>
<td>□ I am able to engage in all my recreation activities with some pain in my neck.</td>
</tr>
<tr>
<td>□ I am able to engage in most but not all of my usual recreation activities.</td>
</tr>
<tr>
<td>□ I am able to engage in a few of my usual recreation activities.</td>
</tr>
<tr>
<td>□ I can hardly do any recreation activities because of pain in my neck.</td>
</tr>
<tr>
<td>□ I cannot do any recreation activities at all.</td>
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**Pain Scale:**

Rate the severity of your pain by checking one box on the following scale:

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<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Excruciating Pain</th>
</tr>
</thead>
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