Investigation into the Origin of Cavitation Sounds During Spinal Manipulation

A dissertation in partial compliance with the requirements for a Master's Degree in Technology in the Department of Chiropractic at Technikon Natal

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I, Roberto Beffa, do hereby declare that this work is my own, both in conception and execution, except where otherwise indicated in the text.

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DEDICATION

This research is dedicated to my parents, Bruno and Lea Beffa.

Thank you for giving me opportunities and for your unwavering belief in me.

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ABSTRACT

[?] Cavitation sounds heard during chiropractic adjustments and manipulations to th extension spine are a common phenomena yet their significance is disputed, the mechanism of their production is a matter of speculation, and their origin has never been localized. (Lewit 1978: 4, Grieve 1989; 525)

The purpose of this study was to locate the joints which cavitate during the performance of a L5 spinous hook adjustment and a lower sacroiliac adjustment. It was hypothesised that the cavitation sounds would arise from the L4-L5 and L5-S1facets on the side of contact during the L5 hook adjustment., and from the the sacroiliac joint on the side being adjusted during the lower sacroiliac adjustment. It was also hypothesised that the two adjustments would differ significantly in terms of the cavitation sounds produced.

Volunteers were screened for agreement with the inclusion criteria. Of these 30 asymptomatic between the ages of 18 and 30 were selected. This was sample was then randomly divided into two groups of, one of which recieved the L5 hook adjustment and the other the lower sacroiliac adjustment.

All of the subjects had eight microphones taped to the skin, over the relevant facets and the sacroiliac joints. Radiographic confirmation was used in order to ensure proper positioning of the microphones. The microphones were then connected to filters, amplifiers and a computer which recorded any sound signals registered during the adjustments.

The data was analyzed using Wilcoxon's signed rank test for intra-group analysis and the Mann-Whitney U test for inter-group analysis.

The results indicated that no statistically significant correlation exists between the anatomical location of cavitation sounds and the adjustment technique selected. Further more, the sounds recorded during the two adjustments did not differ significantly.

This study supports the findings and sentiments of authors such as Grieve (1989: 525) and Herzog et al. (1995) who reject the clinical significance of the cavitation sound during the adjustment.

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DEFINITION OF TERMS

CAVITATION SOUND/S

These are the audible cracking sound/s are often produced during an adjustment or manipulation (Sandoz, 1976).

FIXATION

Is the chiropractic term used to describe dysfunction in a joint in terms of movement (Gatterman, 1990. xix). It is clinically demonstrated by motion palpation (Schafer and Faye, 1989: 213-216).

JOINT DYSFUNCTION

Joint dysfunction implies the loss of one or more movements within the normal range of motion and associated pain (Schafer and Faye, 1989: 27).

LOWER SACROILIAC ADJUSTMENT

This is one of the chiropractic adjustive techniques used to mobilise a fixated sacroiliac joint. (Szaraz, 1990: 9.2)

SPINOUS PULL (HOOK) ADJUSTMENT

This is one of the chiropractic adjustive techniques used to mobilise a fixated lumbar vertebra. (Szaraz, 1990. 9.12)

CHAPTER 1

INTRODUCTION

In the case of mechanical lower back pain, the chiropractor identifies lumbar or sacroiliac joint dysfunction using relevant orthopaedic tests such as Kemp's test (Gatterman 1990: 141), Faber-Patrick's test, Erichson's test and Gaensleans' test (Haldeman 1992 :219) . Once the symptomatic joint is identified it is further examined for restricted motion using the technique of motion palpation (Schafer and Faye 1989: 213-216). This information is then used in selecting an appropriate adjustive technique which is aimed at restoring normal motion patterns to the affected joint (Haldeman 1992: 221). Accuracy in delivering the adjustive force therefore seems to be very important. However, the specificity of an adjustment seems to be limited by the fact that each lumbar vertebra is involved in four facet joints (Bogduk and Twomey 1991:4) thus any one or all of these may be cavitated during adjustment of the lumbar spine. The limitations of sacroiliac joint adjustment seem even greater due to the strong ligaments surrounding this joint (Moore 1985: 341) suggesting that significant separation as associated with cavitation is at least very difficult.

The cavitation or cracking sound is a common occurrence during a manipulation or an adjustment (Sandoz 1976). According to some authors it is a sign that the procedure has been performed correctly and thus will have the desired therapeutic effect. (Lewit 1978: 4). However, other authors contest the clinical significance of the cavitation sound (Grieve 1989: 525). It is believed that the cavitation sounds are produced when the articular surfaces of the joint are sufficiently separated during an adjustment. (Roston and Haines 1947., Unsworth et al. 1971., Meal and Scott 1986).

The source of these sounds has never, to the authors knowledge, been investigated in the lumbarsacral spine. The aim of this investigation is to evaluate the effects of two different chiropractic adjustive techniques performed on the fifth lumbar vertebra and the sacroiliac joint in terms of the origin of the cavitation sounds produced in order to determine whether these techniques resulted in significantly different areas of joint cavitation.

The first objective was to determine the effect of the L5 pull adjustment in terms of the origin of the cavitation sounds produced.
The second objective was to determine the effect of the lower sacroiliac adjustment in terms of the origin of the cavitation sounds produced.
The third objective was to compare the results of objectives one and two in order to determine whether these techniques resulted in significantly different areas of joint cavitation.

It is hoped this study will increase the understanding of the effects of these chiropractic techniques and thus lead to more effective treatment of lower back pain.

CHAPTER 2

LITERATURE REVIEW

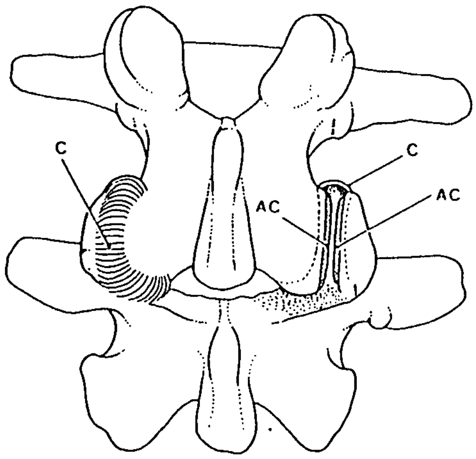
2.1 Introduction

Studies on adjustments and manipulations in association with cavitation sounds have been restricted, mainly, to the third metacarpophalangeal joint. This is possibly because it is the most convenient joint to study due to the ease with which this joint can be cavitated and x-rayed. (Meirau et al. 1988) Research of the cavitation sounds during adjustments to the cervical and thoracic spine has only recently been undertaken by Herzog et al. (1993); Reggars and Pollard (1995) and Gal et al. (1995) and has yet to be done on the lumbar spine and sacroiliac joints.

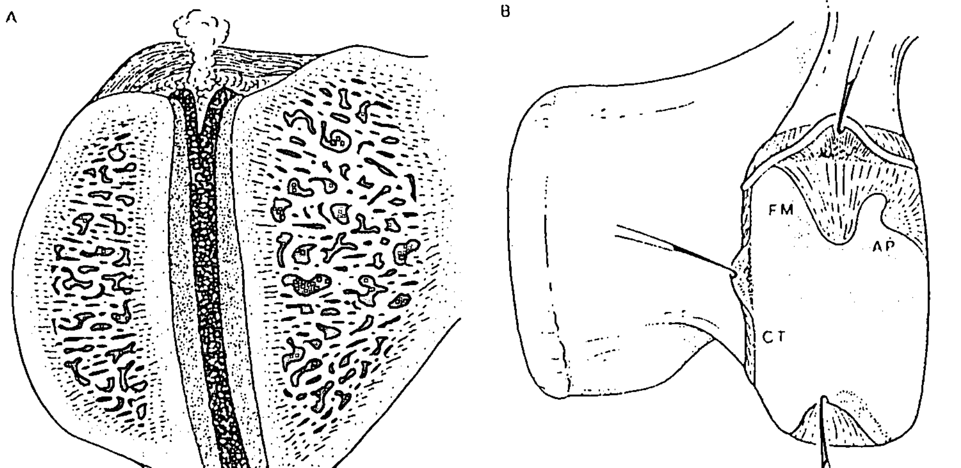
2.2 The Zygapophyseal (Facet) Joint

The zygapophyseal joints are the paired articulations between the inferior articular processes of one vertebra and the superior articular processes of the vertebra below. The relevant anatomy of these joints is illustrated in figure 1.1 below.

Figure 1. 1 The Zygopophyseal Joints



A posterior view of the L3-4 zygapophysial joints. On the left, the capsule of the joint (C) is intact. On the right, the posterior capsule has been resected to reveal the joint cavity, the articular cartilages (AC), and the line of attachment of the joint capsule (broken lines). The upper joint capsule (C) attaches further from the articular margin than the posterior capsule.



Intra-articular structures of the lumbar zygapohysial joints. A: A coronal section of a left zygapophysial joint showing fibro-adipose meniscoids projecting into the joint cavity from the capsule over the superior and inferior poles of the joint. B: A lateral view of a right zygapophysial joint, in which the superior articular process has been removed to show intra-articular structures projecting into the joint cavity across the surface of the inferior articular facet.

The superior capsule is retracted to reveal the base of a fibro-adipose meniscoid (FM) and an adipose tissue pad (AP). Another fibro-adipose meniscoid at the lower pole of the joint is lifted from the surface of the articular cartilage. A connective tissue rim (CT) has been retracted along the posterior margin of the joint.

Taken from Bogduk, N. and Twomey, L.T. 1991: 27, 33

As can be seen in figure 1.1, any one vertebra is involved in the articulations of four facet joints. These joints are diarthrodial in nature. The articular surfaces are covered with hyaline cartilage and each joint is encased in a thin, loose, ligamentous capsule. The capsule is lined by a synovial membrane which secretes synovial fluid, the purpose of the fluid is to allow friction-free movement of the articular surfaces over one another. (Gatterman 1990: 130.; Bogduk and Twomey 1991: 27)

Bogduk and Twomey (1991: 32) note three kinds of intra-articuar structures within the facet joints :-

(a) a connective tissue rim along the anterior and posterior margins of the joints,

(b) an adipose tissue pad at the inferior and superior poles of each joint,

(c) possibly the most significant and largest is the fibro-adipose meniscoid that projects up to 5mm into the joint from the inferior and superior portion of the capsule.

These structures, especially the fibro-adipose meniscoid, may become entrapped between the articular surfaces and cause lower back pain which may be relieved by adjustments (Bogduk and Engel 1984).

According to White and Panjabi (1990: 30) the principle function of the facet joints in the spine is to guide the motion of the particular vertebra. According to Yang and King (1984) the facets absorb between 3% and 25% of the total load of the spine. The major factor that determines the nature and the extent of the motion permitted between two vertebrae is the orientation of the facets at that level (White and Panjabi 1990: 30). The facet joints between the fourth and fifth lumbar vertebrae are orientated, on average, at 48 degrees to the transverse plain and approximately perpendicular to it. The facet join between the fifth lumbar vertebra and first sacral segment are orientated, on average, at 53 degrees to the transverse plain and approximately perpendicular to it (White and Panjabi 1990: 32). This facet orientation allows for a mean of 3 degrees rotation between L4 -L5 and a mean of 2 degrees rotation between L5-S1. (Pearcy and Tibrewal 1984). This is significant as the spinous pull adjustment (Szaraz 9.12) to be used on the fifth lumbar vertebra attempts to induce a rotatory movement to the vertebra.

2.3 The Sacroiliac Joint

This joint is a diarthrodial c-shaped articulation with the convex contour facing anteriorly. The joint space between the articular cartilages is thin and is marked by elevations of the joint surface which increase with age. Before puberty the joint surfaces are flat and smooth. After puberty ridges develop on the iliac side with corresponding depressions on the sacral side. An unusual feature of the sacroiliac joint is that the cartilage appears to be hyaline on the sacral side, and fibrocartilage on the iliac side. The joint space is enclosed by a fibrous capsule. Several strong ligaments stabilise the joint. These are the posterior sacroiliac ligaments, interosseous ligaments, sacrospinous ligaments, sacrotuberous ligaments and the iliolumbar ligaments. (Gatterman 1990:112.; Alderink 1991)

The sacroiliac joint undergoes degenerative changes from early in life, in males as early as the third decade and 10-20 years later in females, and therefore movement of the joint probably decreases with age (Cassidy 1992). It is for this reason that candidates over the age of thirty years will be excluded from the study.

The principle function of the sacroiliac joint is weight-bearing and shock-absorbing for the base of the spine. (White and Punjabi 1990: 112) There is consensus that the sacroiliac joints move (Cassidy and Mierau 1992: 215), but the nature of the movements are obscure. The joint is surrounded by powerful muscles, none are known to move the joint directly (Cassidy 1992). Gatterman (1990: 113) states that motion of the sacroiliac joint occurs primarily in the oblique saggital plain to the order of 3 - 5 degrees. There must be some doubt as to whether it is at all possible to induce enough joint separation in the sacroiliac joint during an adjustment to cause cavitation due to it's early degeneration, and the fact that it is surrounded by strong ligaments and muscles.

2.4 Adjustments and Manipulations

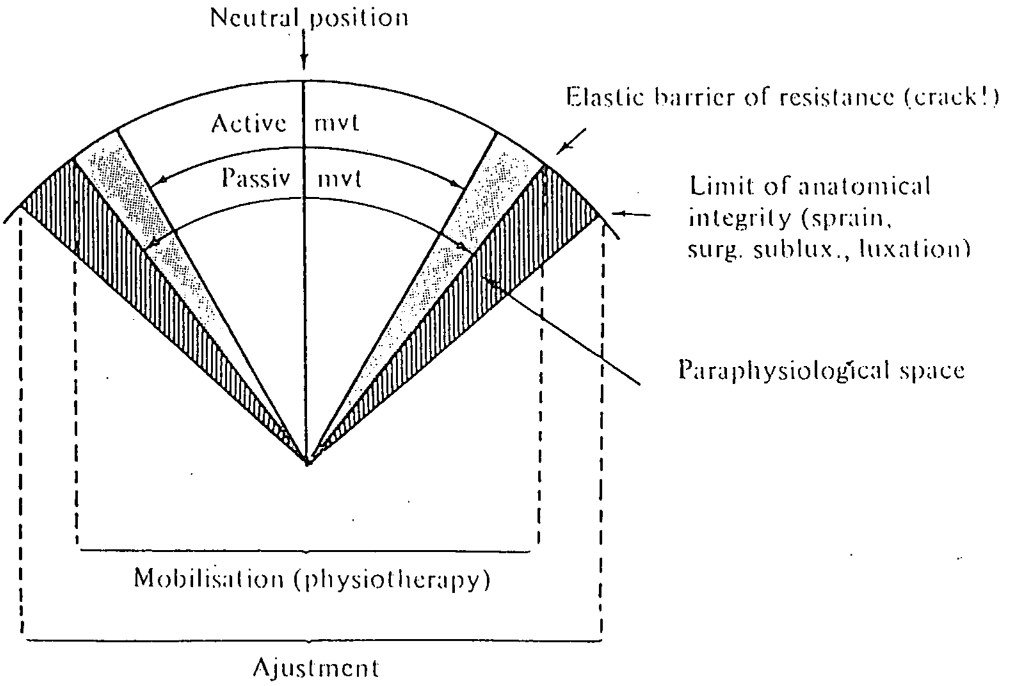
"The chiropractic adjustment utilises specific short levers to which a high-velocity thrust of controlled amplitude is directed with the aim of restoring mobility to the individual articulation." (Gatterman 1990: 49)

The term manipulation seems to include a broad spectrum of manual therapies. Physiotherapists identify manipulation as a grade 5 mobilisation. Grade 1 and 2 mobilisations are oscillatory movements (small and large amplitude respectively) that take the joint up to and slightly past the first tissue stop. A grade 5 mobilisation, also called a thrust manipulation, is a "fast, small-amplitude high-velocity nonoscillatory movement that begins at the first tissue stop and takes the joint through the first tissue stop". (Edmond 1993: 18)

The chiropractic adjustment techniques differ from the manipulative technique in that short levers are used specifically in order to mobilise one particular articulation without affecting neighbouring articulations (Gatterman 1990:49). Whereas a manipulation will include procedures that use long levers in order to induce movement in the general area (Gatterman 1990: 49; Leach 1994: 16.). Both procedures can produce cavitation sounds (Sandoz 1976; Mierau et al. 1988.).

Sandoz (1976) describes movement of a normal diarthrodial joint in the form of several zones and barriers (Fig. 1.2). Starting with active movement, which has the narrowest range of motion it is followed by passive movement, which is slightly more. The end of passive movement describes the end of the "physiological zone" which is characterised by resistance to further motion and is termed the "elastic barrier" (first tissue stop). If the articulation is forced beyond this barrier, a sudden "give" is perceived and is accompanied by the cavitation or "cracking" sound. This extended range of motion is said to be the "paraphysiological zone" which is achieved by manipulation or adjustment. Meirau et al. (1988) showed an increase in range of motion in metacarpophalangeal joints that cavitated in comparison

Figure 1. 2 Joint Mobilisation and Adjustment



Schematic representation of the range of movement in mobilisation and adjustment of a normal diarthrodial joint. In passive mobilisation, the range of movement is limited by the elastic barrier of resistance. When the movement is forced beyond this barrier, one enters into the paraphysiological space. At the end of this space, one encounters the barrier of anatomical integrity of the joint.

Taken from Sandoz, R. 1976: 92.

to those that were merely mobilised. The end of this zone is demarcated by a second barrier to further movement and is termed "the limit of anatomical integrity" (second tissue stop). This is due to full stretch of the ligaments and joint capsule. Beyond this limit is the "pathological zone of movement" characterised by ligamentous damage, rupture of the capsule and luxation. The adjustment or manipulation should never enter this latter zone (Sandoz 1976).

2.5 Indications for an Adjustment

Disorders of the lumbar spine for which adjustments to the fifth lumbar vertebra are possibly indicated include : facet joint fixation, facet joint sprain, intervertebral disc herniation, spondylolisthesis, acute paraspinal muscle strain, myofascial trigger point pain, tropism of facets, spinal canal stenosis, degenerative joint disease and degenerative disc disease. (Gatterman 1990: 149-151)

One of the main indications for an adjustment is a symptomatic joint fixation. That is when one vertebra fails to move relative to the adjacent vertebrae during motion palpation as described by Schafer and Faye (1990: 56), or by a "passive movement restriction" as described by Lewit.(1978: 4)

Adjustment to the sacroiliac joint is one of the modalities used to treat sacroiliac syndrome (Haldeman 1992: 221). Loss of joint motion is detected by motion palpation as described by Schafer and Faye (1990: 259-261).

2.6 The Clinical Significance of the Cavitation Sound

Grieve (1989: 525) seems to reject the clinical significance of the cavitation sound stating that "patients are impressed by it and the therapists are interested in it, otherwise there is no especial importance to it". He goes on to state that to regard a manipulation merely as the production of a click by joint gapping is to "greatly restrict its considerable and rightful place in physical medicine". Research by Herzog et al. (1995) seems to support this statement. Herzog et al. (1995) indicated that increased reflex electromyographical activity of surrounding muscles was due to the speed of the adjustment and not the cavitation sound. Lewit (1978: 4), however, maintains that the cavitation sounds are a sign of a successful manipulation. This seems to be supported by the research done by Mierau et al. (1988). Schafer and Faye (1990: 34) concur and state that unsuccessful manipulations that cause pain are usually not accompanied by a cavitation sound.

2.7 The Cavitation Sound

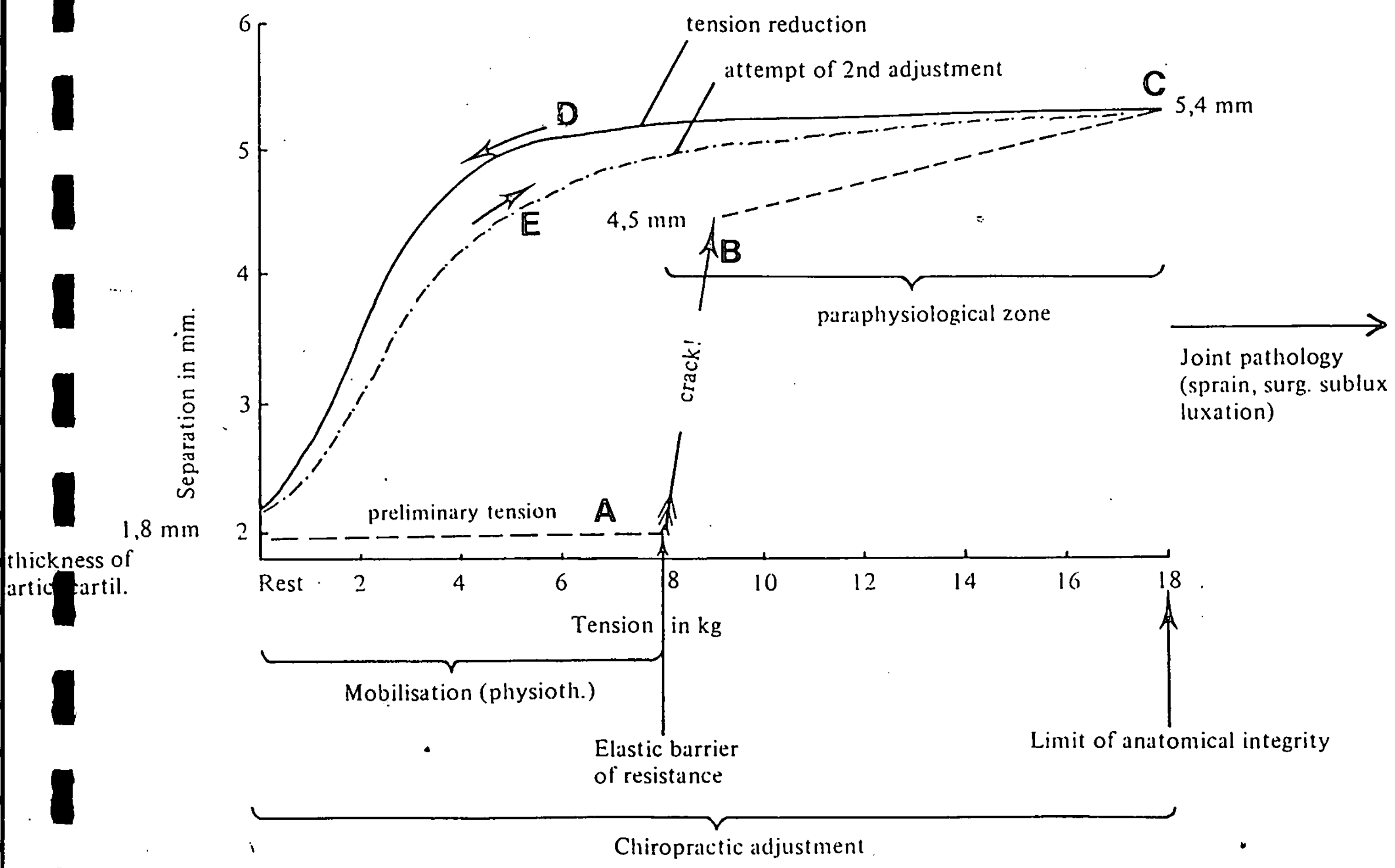
The definition of cavitation according to the Chambers English Dictionary (1988: 228) is "the formation of cavities in a structure, or of gas bubbles in a liquid, or of a vacuum, or of a partial vacuum between a body moving in a fluid and the fluid".

The solubility of gases dissolved in a liquid decreases as the pressure on the liquid is reduced, thus the gases are released from the liquid to form bubbles (Douglas et al. 1992:15). These bubbles may suddenly collapse if the pressure on the liquid increases. The liquid rushes into the collapsing bubble at very high localised pressures (Massey 1991: 90). This pressure can badly erode and damage surrounding surfaces if the frequency of formation and collapse is rapid enough (Douglas et al. 1992: 15). Watson et al. (1989) studied the effect of ultrasonically induced cavitation on bovine cartilage and compared these specimens with osteoarthritic specimens removed during arthroplasty using scanning electron microscopy. The bovine cartilage exposed to 20 minutes of ultrasound showed similar craters to those found in the osteoarthritic specimens. They suggested that the gait cycle could produce the pressure fluctuations that would lead to cavitation taking place in the knee or hip joint, thus resulting in osteoarthritis. No discernible sound is associated with this process. Swezey and Swezey (1975) in a study of 15 habitual knuckle crackers, found that only one showed degenerative disease of the metacarpophalangeal joint in comparison to the control group of 13 non-knuckle crackers, of which 5 showed degenerative disease. Their conclusion was that the data failed to show a correlation between knuckle cracking and degenerative changes in the metacarpophalangeal joint. Castellanos and Axelrod (1990) in their study of habitual joint cracking of the knuckles indicated that the soft tissue of the joint was affected and not the cartilage or bone tissue.

This cavitation, either in it's formation or it's collapse, is thought to cause the sound associated with adjustments (Unsworth, Dowson and Wright 1971.; Chen and Israelachvili 1991). However, the exact mechanism of the sound production is still not fully understood.

The first to investigate the sound was Roston and Haines (1947). They studied the cracking of the third metacarpophalangeal joint using a spring balance attached to the proximal phalanx to measure tension applied to the joint.. Radiographs were taken at intervals to measure the joint space. This enabled them to ascertain the force- displacement relationship of the joint whilst it was being cracked (Fig. 1.3). The graph (fig. 1.3) shows that from an initial value of 1.8mm. the joint space increased with tension (8.5 kg.) in a linear relationship up to a maximum of 2mm (Line A. Fig. 1.3). On cracking, the joint space increased to 4.7mm. at 9 kg. of tension (Line B, Fig. 1.3). A clear space appeared in the radiograph within the joint space, indicating the presence of a gas bubble. Further increases in tension resulted in small increases in the joint space (18.5 kg. of tension resulted in 5.6mm of joint separation)(C, Fig. 1.3). Upon releasing the tension the force-displacement curve followed a smooth path (Line D, Fig. 1.3). When the procedure was repeated several minutes later it was found that the joint could not be cracked again. This persisted for approximately 20 minutes and was termed the refractory period. Roston and Haines (1947) attributed the crack to the formation of a partial vacuum occupied by water vapour and blood gases. They hypothesised that during the refractory period the gases dissolved back into the surrounding tissues.

Figure 1. 3: Adjustment of a Carpo-metacarpal Joint Under Axial Stretch



Taken from Sandoz, R. 1976: 97.

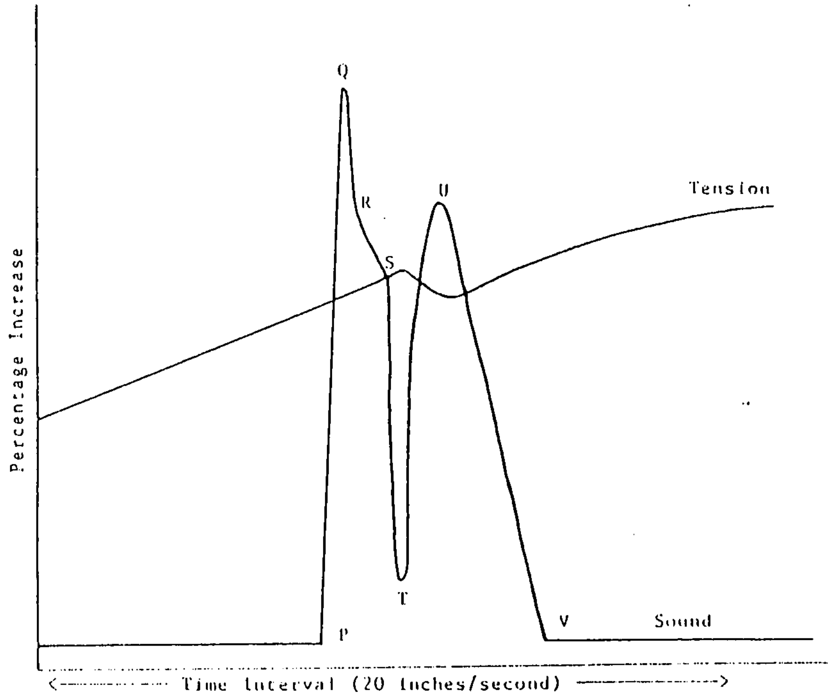
Unsworth, Dowson and Wright (1971) repeated the experiment using a pneumatic cylinder connected to a transducer. X-rays of the third metacarpophalangeal joint were taken at increments up to 16 kg. The results were similar to those of Roston and Haines (1947) except that it was noticed that the joint did not return to it's pre-crack joint interval until after 15 minutes. They tried reloading the joint immediately and found that the force-displacement loading curve differed substantially form the original curve (Line E, Fig. 1.3). Unsworth and co-workers went on to conclude that the cause of the crack was the collapse of the vapour bubble and not it's formation and this was basically the process of cavitation.

Sandoz (1976) was possibly the first to comment on the work of Roston and Haines (1947) and Unsworth, Dowson and Wright (1947) with respect to chiropractic and spinal adjustments. He proposed that when traction is applied to a joint, the articular capsule and synovial folds become invaginated into the joint due to a slight negative pressure that exists within the joint space. According to Sandoz (1976) this negative pressure is responsible for the coaptation of joint surfaces which is a factor in joint stability. The pressure has been measured as -1.6mmHg in the human knee (Spencer et al. 1984) but no literature can be found on the pressure in the zygapophyseal or sacroiliac joints. This continues until the elastic barrier of the articular capsule is reached. If the joint is tractioned further, gases are liberated from the synovial fluid allowing for an increase in joint volume. Consequently the pressure within the joint increase from a negative value to atmospheric levels. The presence of the bubble in the joint and the change in the pressure reduces the coaptative forces of the joint and thus leads to a temporary increase in the range of motion for the duration of the refractory period.

Using high speed cine' of a nylon simulated joint, Unsworth, Dowson and Wright (1971) showed that the bubble forms and collapses within 0.01 seconds. Watson and Mollan (1990) investigated the cracking of the third metacarpophalangeal joint using cineradiography of the joint and their results indicated that the bubble was formed and collapsed within 8.3 milliseconds. This is in contrast to Meal and Scott (1986) who reported the duration to be between 25 and 75 milliseconds. Mierau et al. (1988) in their study on manipulation and mobilisation of the third metacarpophalangeal joint reported that 39 out 42 joints that were cracked showed visible gas arthrograms on radiographs when 6 lbs. of post-treatment traction was applied.

Meal and Scott (1986) analysed the joint crack by simultaneous recording of joint cavitation and tension on the metacarpophalangeal joint of the middle finger and noted that the shape of the sound wave produced was very constant (Fig. 1.4). The sound was recorded as a double wave and the separation of the joint surfaces started between the two waves. This is possibly very important, indicating that the process of a joint crack is possibly more than a simple cavitation. They also made recordings of cavitation sounds in the cervical spine during adjustments and noted that the wave forms were similar to those produced by the metacarpophalangeal joint and therefore concluded that the noises arise from the synovial joints of the spine.

Figure 1. 4: A Typical Metacarpophalangeal Joint Crack

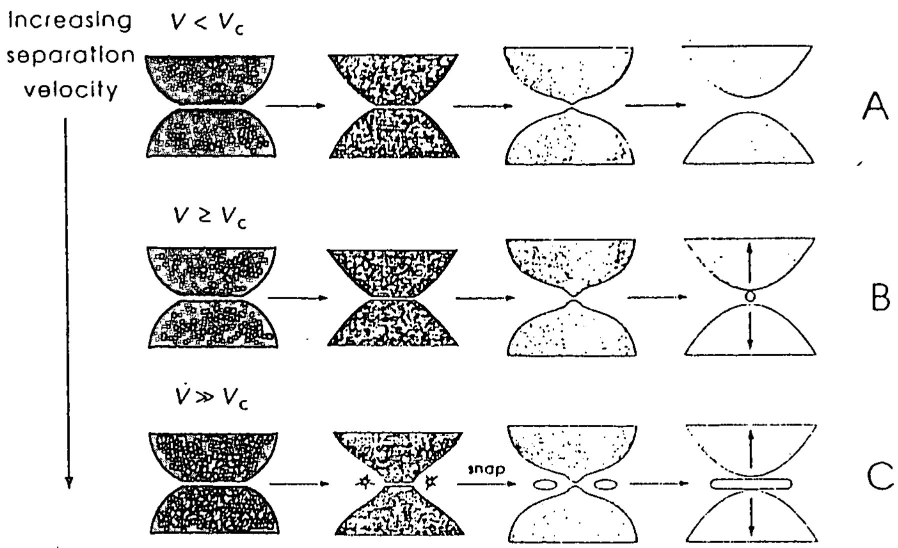


A typical sound wave from a metacarpophalangeal joint crack with the tension trace superimposed.

Taken from Meal, G.M. and Scott, R.A. 1986: 193.

Some of the most interesting work done on joint cavitation was that by Chen and Israelachvili (1991) in their study on the mechanics of cavitation damage. They used a model made of mica that closely resembled an articular joint and experimented with different separation velocities of the model articular surfaces (Fig. 1.5).

Figure 1. 5: A Cavitation Mechanism



A cavitation mechanism. This figure shows two mica surfaces in a viscous fluid and the behavior of these surfaces as they are separated from each other at different separation velocities. A. The separation velocity is below the critical value. No cavitation results. B. The separation velocity is greater than or equal to the critical value. Cavitation occurs as the two mica surfaces snap back, fracturing the fluid and forming a vapor cavity. C. The separation velocity is much larger than the critical value. A doughnut-shaped cavity forms as a large section of the surfaces snap back. Adapted from Chen and Israelachvili

Taken from Brodeur, R. 1995: 159.

They noticed that below a certain velocity (<0.05um/s) cavitation failed to occur but the surfaces did evaginate (sic) at the area of contact during separation (Fig 1.5). As the separation velocities were increased above a critical value (~1um/s) a crack formed in the liquid between the surfaces allowing the evaginated surfaces to snap back to their original shape.

When the separation velocity was further increased cavitation occurred in a doughnut shape around the surface contact areas even before evagination had taken place. The cavity then coalesced, as the surfaces separated, into a single central bubble that proceeded to collapse. This could possibly explain the double wave recorded by Meal and Scott (1986), the first being articulator surface snap back, the second being the bubble collapse. Unfortunately, there is no indication of the time for the bubble formation, and sound recordings were not included in their experiment.

Brodeur (1995) suggests a model of cavitation based on Chen and Israelachvili's (1991) and Sandoz's (1976) work. In this model, cavitation occurs at the capsular/ synovial fluid interface rather than between the joint surfaces. As the surfaces are separated, the capsule is invaginated to keep the joint volume constant to the point where the elastic energy in the capsule causes it to snap back rapidly. This causes cavitation to occur at the capsular/ synovial fluid interface and a sudden increase in joint separation. Brodeur (1995) attributes the double sound wave recorded by Meal and Scott (1986) to the snap-back of the capsule and the sudden increase in capsule tension as the joint reaches maximum displacement. This also explains why a drop in joint tension has been recorded between the two sound peaks that has been found by Meal and Scott (1986).

2.8 Cavitation of the Spinal Joints

Possibly the first recordings of cavitation sounds in the spine was done by two dentists, Woods and West (1986). With the help of chiropractors they recorded cavitation sounds of cervical, thoracic and lumbosacral joints during manipulation and compared them to temporomandibular joint (TMJ) sounds. They concluded that there was little reproducibility of the wave form from one manipulation to the next, and that the manipulated sounds were significantly different form TMJ sounds. Unfortunately they did not specify the kind of adjustments that were used.

Conway et al. (1993) investigated the forces required to cause cavitation during manipulation in the thoracic spine. One chiropractor manipulated the fourth thoracic vertebra (T4) vertebra with an posterior to anterior thrust on ten patients. The cavitation signals were detected using an accelerometer taped on to the spinous process of the T3 vertebra, and the force of the thrust was measured using a flexible pressure mat. In 8 out of the 10 trials cavitation occurred before the peak force of the thrust was delivered. In the remaining two thrusts cavitation occurred after the peak force of manipulation. Conway et al (1993) concluded from this that cavitation is a "function of a complex interaction of many mechanical variables".

Herzog, et al. (1993) then conducted a similar study on 20 symptomatic patients. The patients were treated in the prone position using a reinforced unilateral contact on the transverse process of the T4 vertebra in an posterior to anterior direction. The patients were given a normal (high-velocity) thrust and 18 patients were also given a treatment where the force was applied over 3 to 10 seconds. In 17 of the 20 normal treatments and 3 of the 18 slow treatments the chiropractor indicated that cavitation had occurred. This was confirmed by a cavitation signal from the accelerometer. In the other treatments no cavitation signals were recorded.

The cavitation signals were typically triphasic and approximately 20 milliseconds in duration.

Gal, et al. (1995) compared the relative movements between adjacent vertebra that were accompanied by cavitation sounds to the relative movements of vertebra that were not accompanied by a cavitation signal. This was done by using high speed cinematography and embedded bone pins to analyse the movements of T10, T11 and T12 in one 77 year old male cadaver. Two accelerometers were attached to the skin over either T10 and T11 or T11 and T12. The bone pins were placed into T10, T11 and T12 and two high speed cine cameras were placed saggitally and transversely to the cadaver. A clinician delivered five high speed posterior to anterior thrusts to the right transverse process of T12 at 10 minute intervals. During the fourth manipulative thrust a cracking sound was heard and a high frequency biphasic acceleration was recorded by the T12 accelerometer over and above the lower triphasic acceleration recorded during the other thrusts. This was interpreted as a cavitation signal. There appeared to be no correlation between the magnitude or rate of applied force and cavitation. When the relative movements of the vertebra were analysed it was noticed that the left lateral translation (relative to the cadaver) was considerably larger than that of other thrusts and thus possibly associated with an increased shearing force. It is difficult to ascertain anything definite from this research due to the small sample size and the possibility that vertebral movement and cavitation may be considerably different in post-rigor cadavers than in the in-vitro subjects. Reggars and Pollard (1995) investigated cavitation sounds in the cervical spine during manipulation. They researched the relationship between the side of head rotation and the side of joint cracking during diversified rotatory manipulations to the cervical spine. Forty-seven of the fifty subjects exhibited "cracking" sounds on the ipsilateral side of head rotation. The average length of the "cracking" sounds was 4 milliseconds and no consistent wave form could be established.

2.9 Conclusion

The literature seems to indicate that obtaining a cavitation sound may be of some importance when performing an adjustment but it is clear that little is conclusively known regarding the events that lead up to and during the cavitation of a joint, let alone the source of the sound/s.A study of this kind has never been undertaken in the lumbar spine and pelvis, there is absolutely no information on the nature or location of the sounds that arise form this area during adjustments. Thus this study hopes to pilot the way in a new area of research of using cavitation sounds as a tool to further the understanding of chiropractic adjustments.

If the source of the cavitation sound/sounds can be identified during adjustments to the lumbar spine and pelvis then, hopefully, these adjustments can be used with greater understanding and improved clinical efficacy and lead to more intensive research on the nature of the sound.

CHAPTER 3

MATERIALS AND METHODS

3.1 The Objective

This study proposed to determine the origin of the cavitation sound/s produced during the performance of the lumbar spinous hook adjustment and the lower sacroiliac adjustment.

3.2 The Data

The data for this research is of two types: primary and secondary data. The primary data was collected by the experimental method. It was indicated by the number of cavitation signals recorded by each of the eight microphones during the two chiropractic adjustments. The secondary data was obtained from literature on joint cavitation.

3.3 The Research Methodology

3.3 1 Subjects

A sample size of 30 participants was selected from the students of the Department of Chiropractic at Technikon Natal. All participants had to comply with the delimitations of the study.

The delimitations were:

- All candidates were males. This is due to the fact that x-rays were taken of all the participants and it was deemed unethical to expose the female gonads to radiation unnecessarily.
- All candidates were between the ages of 18 and 30. This was to exclude the possibility of degenerative ankylosis of the sacroiliac joints as described by Cassidy (1992).
- All candidates had to have no history of injury to the lumbar spine and/or pelvis.
- Any candidate found to have an abnormality of the lumbar spine or pelvis during the physical or x-ray examination was excluded from the study.
- Only candidates who had signed the Informed Consent Form were allowed to participate in the study.

Thirty-six students volunteered for the study and all 36 were found to be eligible for the study. Six subjects were excluded during the course of the study for the following reasons:

- two participants were unavailable during the actual execution of the study.
- one participant had injured his lower back just prior to the execution of the study.
- three participants were excluded as no audible cavitations were achieved during the study even though several attempts were made to achieve them.

3.4 The Experimental Design

The subjects were randomly divided into two groups of 15. Group 1 received the lumbar spinous hook adjustment (Szaraz 9.12) and Group 2 received the lower sacroiliac adjustment (Szaraz 9.3). Patients were not given the option of which adjustment they preferred to ensure random selection took place.

The process of randomisation was done as follows: The numbers 1 to 30 were listed on a page. Thirty identical folded labels, fifteen marked P (lumbar pull adjustment) and fifteen marked S (lower sacroiliac adjustment) were placed in a hat and mixed. As the labels were drawn from the hat, in sequence from one to thirty, the letters were recorded on the list next to the numbers in the sequence they were drawn. The labels were then discarded. The participants were then allocated to one of the groups according to their individual entry number.

On volunteering for the study the participants individually attended an initial consultation and a trial consultation. The events at each of these consultations was as follows.

Initial Consultation

The subjects signed an Informed Consent Form (Appendix A) once the nature of the study had been carefully explained to them. Then the full history, physical and regional examinations were completed (Appendices B, C and D). These examination findings were used to establish adherence to the delimitations.

The Trial Consultation

Eight microphones were placed in rubber grommets (the rubber stands found on the bottom of computer towers),then on the skin over the zygapophyseal joints of the fourth and fifth lumbar vertebrae and the posterior superior iliac spine using adhesive tape (Fig. 6). Initial placement of the microphones was done in relation to palpable bony landmarks of the lumbar spine and sacroiliac region. The bony landmarks used were the spinouses of L4 and L5 vertebra and the posterior iliac spines. The facet joints of L3-L4, L4-L5 and L5-S1 were estimated to be lateral to the interspinous space of the respective vertebrae. For convenience the microphones were placed 3 cm. lateral to the midline. This placed the microphones slightly laterally to the zygapophyseal joints and served to increase the distance between microphones on opposite sides of the spine in order to decrease the possibility of contralateral cavitation signals being registered. The microphones were numbered 0 through to 7. The microphones were placed as follows:

Microphone 0 -right L3-L4 facet

Microphone 1- left L3-L4 facet

Microphone 2- right L4-L5 facet

Microphone 3-.left L4-L5 facet

Microphone 4-.right L5-S1 facet

Microphone 5-.left L5-S1 facet

Microphone 6- right posterior superior iliac spine

Microphone 7-.left posterior superior iliac spine

Figure 2. 1: A lumbar Spine X-ray

The participant was then radiographed. One anterior-to-posterior view of the lower lumbar spine and sacroiliac joints was taken to ensure proper placement of the microphones (Fig. 2.1).

If the microphone placings were found to be incorrect their positions were altered and a final radiograph taken for confirmation. A maximum of two radiographs was taken per subject. If the microphone placement was incorrect or a successful adjustment did not take place after the patient had had two radiographs, he was dismissed from the study.

The microphones were then connected to the filtering and amplification unit and computer (Appendix E). All subjects were placed in the left lateral recumbent position for the execution of the selected adjustments for the respective groups . In some candidates several attempts were made to achieve an adjustment that produced audible cavitation sound/sounds.

The microphones detected the cavitation sounds which were then amplified, filtered and fed into the computer which digitilised the analogue signal. Graphs (Appendix F) of each microphone for the adjustments on each subject were plotted from the computer thus indicating the location and relative intensity of the resulting cavitation/s.

At the completion of all the trial consultations for both groups the data as an entirety was collated, analysed and interpreted via statistical methods.

3.5 The Specific Treatment of the Data

The data obtained was analysed statistically using the software programme Statographics Plus version 6 supplied by Manigestics Inc. The following tests were used:

- The Mann- Whitney U test to compare the experimental and control groups (intragroup analysis)
- The Wilcoxon's Signed Rank test to compare within the groups (intergroup analysis)
- Summary statistics

CHAPTER 4

RESULTS

4.1 The Criteria for the Admissibility of the Data

- Data was only taken from the recordings of the adjustments done by the researcher.
- Data of the recordings was only used if audible cavitations were heard by the researcher during the adjustment.

4.2 Demographic Data

Table 4. 1: Age Distribution

	L5 PULL	LOWER SACRO-ILIAC	TOTAL
AGE RANGE	20-28	19-27	19-28
AVERAGE AGE	23.66	23.53	23.6

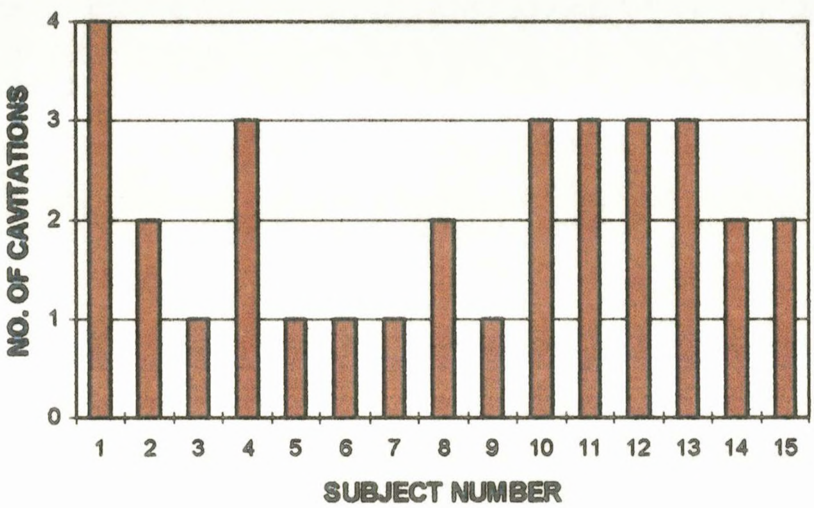
Table 4. 2: Race Distribution

	L5 PULL	LOWER S.I.
WHITE	15	14
INDIAN	0	1

3.4 Objective 1

Determination of the effect of a lumbar (L5) pull adjustment in terms of the origin of the cavitation sounds produced.

GRAPH 4. 1: Number of Cavitations per Subject- L5 Pull

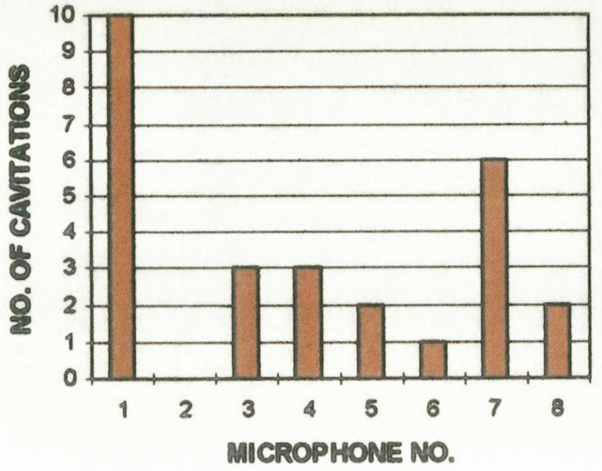


Average number of cavitations per subject = 2.13

Range = 3

Standard Deviation = 3.204

GRAPH 4. 2: Number of Cavitations per Microphone- L5 Pull



MICROPHONE POSITION KEY

0	1	2	3	4	5	6	7
RIGHT L3-L4	LEFT L3-L4	RIGHT L4-L5	LEFT L4-L5	RIGHT L5-S1	LEFT L5-S1	RIGHT P.S.I.S.	LEFT P.S.I.S.

Average number of cavitations per microphone = 3.37

Range = 9

Standard Deviation = 3.204

Results of the Wilicoxon's Signed Rank Test.

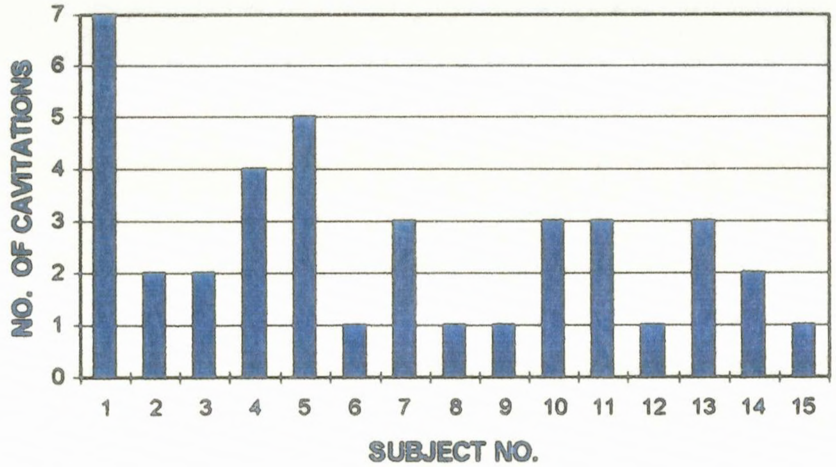
Exceedence probability value (p-value)=0.1876 at the 5% level of significance.

The null Hypothesis is accepted for the L5 pull adjustment group which indicates there is no significant association between the microphones in this group.

4.4 Objective 2

Determination of the effect of a Lower Sacroiliac adjustment in terms of the cavitation sounds produced.

GRAPH 4. 3: Number of Cavitations per Subject: Lower Sacroiliac Adjustment

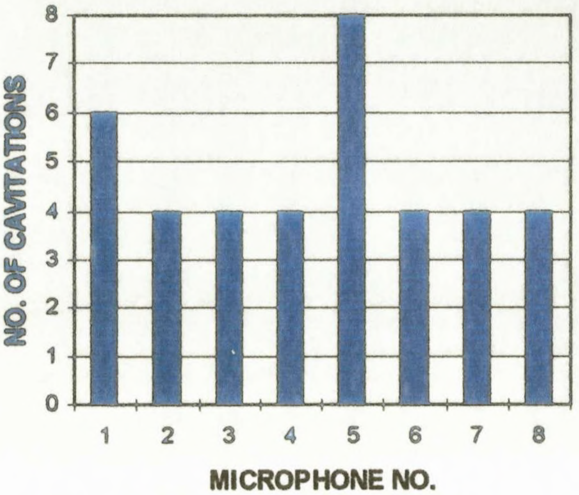


Average number of cavitations per subject = 2.6

Range = 6

Standard Deviation = 1.732

GRAPH 4. 4: Number of Cavitations per Microphone: Lower Sacroiliac Adjustment



MICROPHONE POSITION KEY

0	1	2	3	4	5	6	7
RIGHT L3-L4	LEFT L3-L4	RIGHT L4-L5	LEFT L4-L5	RIGHT L5-S1	LEFT L5-S1	RIGHT P.S.I.S.	LEFT P.S.I.S.

Average number of cavitations per microphone = 4.22

Range = 4

Standard Deviation = 2.108

Results of the Wilcoxon's Signed Rank Test.

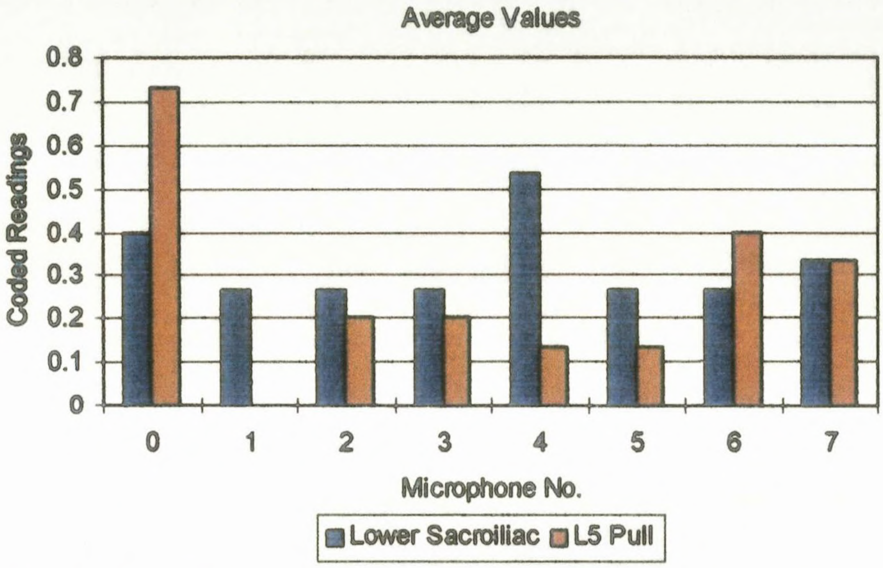
Exceedence probability value (p-value)=0.355 at the 5% level of significance.

The null Hypothesis is accepted for the Lower Sacroiliac adjustment group which indicates there is no significant association between the microphones in this group.

4.5 Objective 3

Cimparison of the data from objectives 1 an2 in order to determine whether there is a significant difference in areas of joint cavitation.

GRAPH 4. 5: Comparison of Cavitation Signals



MICROPHONE POSITION KEY

0	1	2	3	4	5	6	7
RIGHT L3-L4	LEFT L3-L4	RIGHT L4-L5	LEFT L4-L5	RIGHT L5-S1	LEFT L5-S1	RIGHT P.S.I.S.	LEFT P.S.I.S.

Results of the Mann-Whitney U Test.

The p-value = 0.2102 at the 5% level of significance

The null hypothesis is accepted, and conclude that there is no significant difference between the two groups.

CHAPTER 5

DISCUSSION

This chapter covers the discussion of the results from the microphone recordings presented in the previous chapter.

The Wilcoxon's Signed Rank Test of the microphone recordings during the L5 hook and Lower Sacroiliac adjustments resulted in the acceptance of the null hypothesis ($p<0.05$ for all statistical tests) for both groups. This indicates that no joints were cavitated frequently enough to signify specificity during either of these adjustments. It was expected that the cavitation sounds would be localised to the superior and infe~~r~~ior L5 facets during the L5 hook adjustment, and to the sacroiliac joint being adjusted during the lower sacroiliac adjustment.

The Mann-Whitney U test for the microphone readings during the two adjustments resulted in the acceptance of the null hypothesis. This indicates that there was no significant difference between the two groups.

The research seems to indicate that the cavitation of the joints in the lumbar spine and pelvis during these two adjustments is random. This contradicts the statements by Lewit (1978:4), Schafer and Faye (1990:34) and Sandoz (1969) on the importance of obtaining a cavitation sound during an adjustment as the sounds could be from joints other than those desired. However, it does lend weight to the study done by Herzog et al. (1995) that indicates that increased reflex electromyographical activity of the surrounding muscles was due to the speed of the adjustment and not the cavitation sound, therefore it seems that the manoeuvre is of importance and not the resulting cavitation sounds.

Yet, upon viewing the data, one of the differences noted between the two groups was a higher average number of cavitations produced per individual during the Lower Sacroiliac adjustment than during the L5 pull adjustment. This is possibly due to the contact on the ilium which acts as a long lever contact for the lumbar spine rather than a short lever for the sacroiliac joint and should therefore possibly be viewed as a manipulation rather than a specific adjustment.

Another aspect of interest from the data is that the microphone that recorded the highest number of signals during the L5 pull adjustment was placed over the L3-L4 right facet (the upper side during the adjustment). This may be due to the personal technique of the researcher, or possibly the biomechanics of the spine allow for easy cavitation of this joint.

The microphone that recorded the highest number of signals during the lower sacroiliac adjustment was placed over the right L5-S1 facet (upper side during the adjustment). This suggests that what is considered often as a sacroiliac joint cavitation could likely be the lumbar-sacral junction cavitating. This seems reasonable when one considers the strong ligaments and the articular surface of the sacroiliac joint (Cassidy 1992).

When reviewing this study, several areas are evident that could be improved upon. The sample size of the study could be increased and then possibly some significant findings will result. Using the sample size of fifteen per group has possibly led to a Type II Error (Haldeman 1992: 419). However, only one study on cavitation sounds has used a larger sample size than this study, and that was done by Reggars and Pollard (1995) who used fifty. The Studies done by Conway et al. (1993) and Herzog et al. (1993) used sample sizes of ten and twenty respectively. Therefore even though this may be too small statistically, it compares favourably to the other published studies.

Only one adjustor was used in this study, therefore differences in technique of adjusting between chiropractors has not been taken into account. Two chiropractors performing the same adjustment on the same group of individuals may produce vastly different results.

The group of individuals selected for this study were all asymptomatic. A study done on adjustments to fixated (symptomatic) joints would be of immense interest.

Prior to commencement of the actual study, several trails were done with the equipment on volunteers before it was deemed suitable. It was evident from the initial trial that the sensitivity and frequency range of the equipment would have to be adjusted to be selective for the cavitation signals. Foreign sounds such as movement of the subject on the adjusting bed would then be limited. To ensure that the microphones did not lie at an angle to the skin they were placed in rubber grommets before being taped to the skin. It was found that this helped dampen background noise and improved reception of the cavitation signals. Further limitations of the equipment used have since been identified during the study (Appendix G), and can therefore be improved.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

This study indicates that neither adjustment is associated with the cavitation of any joint/s sufficiently frequently to be of statistical significance. More than this can not be concluded from this study.

It must be noted that a investigation of this kind has never been attempted before and therefore it has shown that research of this nature is possible. It is recommended that the study be considered a trial study, to be followed by a more comprehensive study to further investigate the cavitation phenomenon. An increased sample size and numerous adjustors might produce significant results. Improvements on the equipment used for this study, to cater for a wider range of frequencies and amplitudes, could add significantly to the body of knowledge in this new area of research.

Future studies involving symptomatic subjects and other adjustive techniques are also suggested.

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APPENDICES

APPENDIX A

INFORMED CONSENT FORM

(To be completed in duplicate by patient/subject*) *Delete whichever is not applicable.

TITLE OF RESEARCH PROJECT

____

____

NAME OF SUPERVISOR

____

NAME OF RESEARCH STUDENT

____

PLEASE CIRCLE THE APPROPRIATE ANSWER

1. Have you read the research information sheet? YES/NO

2. Have you had an opportunity to ask questions regarding this study? YES/NO
3. Have you received satisfactory answers to your questions? YES/NO

4. Have you had an opportunity to discuss this study? YES/NO
5. Have you received enough information about this study? YES/NO

6. Who have you spoken to? ______________________________

7. Do you understand the implications of your involvement in this study? YES/NO

8. Do you understand that you are free to withdraw from this study? YES/NO
   a) at any time
   b) without having to give a reason for withdrawing, and
   c) without affecting your future health care.

9. Do you agree to voluntarily participate in this study? YES/NO

PATIENT/SUBJECT* Name____________________ Signature__________________
(in block letters)

PARENT/GUARDIAN* Name____________________ Signature__________________
(in block letters)

WITNESS Name____________________ Signature__________________
(in block letters)

RESEARCH STUDENT Name____________________ Signature__________________
(in block letters)

APPENDIX B1

TECHNIKON NATAL CHIROPRACTIC DAY CLINIC

CASE HISTORY

Patient: ______________________ Date # __________

File #: __________

X-ray #: __________

Age: ________ Sex: ______ Occupation: __________

Intern: ______________________ Signature: __________

FOR CLINICIAN'S USE ONLY

Initial visit clinician: Signature:

Case History:

Examination:
Previous: TN
Other
Current: TN
Other

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

Clinical path. lab.:
Previous: TN
Other
Current: TN
Other

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

Recommendations:

APPENDIX B2

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 S & S

   Previous occurrences

   Past treatment and outcome

APPENDIX B3

4. Other complaints:

5. Past history:

   General health status

   Childhood illnesses

   Adult illnesses

   Psychiatric illnesses

   Accidents/injuries

   Surgery

   Hospitalizations

6. Current health status and life-style:
   - Allergies
   - Immunizations
   - Screening tests
   - Environmental hazards (home, school, work)
   - Safety measures (seat belts, condoms)
   - Exercise and leisure
   - Sleep patterns
   - Diet
   - Current medication
   - Tobacco
   - Alcohol
   - Social drugs

7. Family history:
   - Immediate family:
     - Age
     - Health
     - Cause of death
     - DM
     - Heart disease
     - TB
     - HBP
     - Stroke
     - Kidney disease
     - CA
     - Arthritis
     - Anaemia
     - Headaches
     - Thyroid disease
     - Epilepsy
     - Mental illness
     - Alcoholism
     - Drug addiction
     - Other

APPENDIX B5

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

APPENDIX B6

Genital

Vascular

Musculoskeletal

Neurologic

Haematologic

Endocrine

Psychiatric.

TECHNIKON NATAL CHIROPRACTIC DAY CLINIC

PHYSICAL EXAMINATION

Underline abnormal findings in RED and elaborate on back of relevant page, if necessary.
Mark "NAD" if normal.

Patient:______________________________ File #______

Last name First name

Clinician:__________________ Signature:__________________

Intern:__________________ Signature:__________________

Date:__________________

Height:____________ Weight:____________ Temp:____________

Rates: Heart:________ Pulse:________ Respiration:____________

Blood pressure: Arms: L / R /

Legs: L / R /

General appearance:

APPENDIX C2

STANDING EXAMINATION.

Minor's sign
Skin changes
Posture
erect
Adam's
Ranges of motion:

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

Flex.

L.Rot. R.Rot.

L.lat flex. R.lat. flex.

Ext.

/ = pain-free limitation; // = painful limitation.

Romberg's sign.
Pronator drift.
Trendelenburg's sign.
Gait.
rhythm
balance
pendulousness
on toes
on heels
tandem
Half squat.
Scapular winging.
Muscle tone.
Spasticity/Rigidity.

APPENDIX C3

Shoulder:
skin
symmetry
ROM - glenohumeral
scapulo-thoracic
acromioclavicular
elbow
wrist
Chest measurement
inspiration
expiration
Visual acuity

Breast examination:
Inspection:
skin
size
contour
nipples
arms overhead
hands against hips
leaning forward.
Palpation:
axillary lymph nodes.

SEATED EXAMINATION.

Spinal posture
Head
scalp
skull
face
skin
Eyes
conjunctiva
sclera
eyebrows
eyelids
lacrimal gland
nasolacrimal duct
alignment
corneal reflex
ocular movement

L			R		
III	IV	VI	III	IV	VI

visual fields
accomodation
iris
pupils
red reflex
optic disc

APPENDIX C4

- vessels
- general background
- macula
- vitreous
- lens

Ears:

- auricle
- ear canal
- drum
- auditory acuity
- Weber test
- Rinne test

Nose:

- external
- internal
    - septum
    - turbinates
    - olfaction

Sinuses (frontal & maxillary):

- tenderness
- transillumination

Mouth and pharynx:

- lips
- buccal mucosa
- gums and teeth
- roof
- tongue
    - inspection
    - movement
    - taste
    - palpation
- pharynx
    - inspection
    - CN X

Neck:

- posture
- size
- swelling
- scars
- discoloration
- hair line

S.

APPENDIX C5

ROM:

Flexion:	45	chin to larynx chin to sternum
Extension:	55	forehead parallel to floor
L.lat.flex:	40	
R.lat.flex:	40	
L.rot.:	70	
R.rot.:	70	

Flex.

L.Rot. R.Rot.

L.Lat. flex. R.lat. flex.

Ext.

lymph nodes
trachea
thyroid
carotid arteries (thrills, bruit)
CN V
CN VII
CN VIII (nystagmus)
CN IX
CN XI
TMJ --
Inspection
ROM
deviation
Palpation
crepitus
tenderness

APPENDIX C6

Neurological:
- Dermatomes
  - C5
  - C6
  - C7
  - C8
  - T1
- Tendon reflexes
  - biceps
  - triceps
  - brachioradialis
- Muscle strength
  - C5
  - C6
  - C7
  - C8
  - T1
- Coordination:
  - point-to-point
  - dysdiadochokinesia

Thorax:
- Chest:
  - Inspection:
    - skin
    - shape
    - respiratory distress
    - rhythm (respiratory)
    - depth "
    - effort "
    - intercostal/supraclavicular retraction
  - Palpation:
    - tenderness
    - masses
    - respiratory expansion
    - tactile fremitus
  - Percussion:
    - lungs (posterior)
    - diaphragmatic excursion
    - kidney punch
  - Auscultation:
    - breath sounds
      - vesicular
      - bronchial
    - adventitious sounds
      - crackles (rales)
      - wheezes (rhonchi)
    - voice sounds
      - broncophony
      - whispered pectoriloquy
      - egophony

Cardiovascular:
auscultation (aortic murmurs)
Allen's test

SUPINE EXAMINATION

JVP
PMI
auscultation heart (L.lat.recumbent)
respiratory excursion
percussion chest (anterior)
breast palpation
The abdomen:
Inspection:
skin
umbilicus
contour
peristalsis
pulsations
hernias (umbilical/incisional)
Auscultation:
bowel sounds
bruit
Percussion:
general
liver
spleen
Palpation:
superficial reflexes
cough
light
rebound tenderness
deep
liver
spleen
kidneys
aorta
intra-/retro-abdominal wall mass
shifting dullness
fluid wave
Acute abdomen:
where pain began and now
cough
tenderness
guarding/rigidity
rebound tenderness
Rovsing's sign
psoas sign
obturator sign
cutaneous hyperaesthaesia
rectal exam

APPENDIX C8

Male genitals and hernias.

Inspection:

skin

prepuce

glans

meatus

nits/lice

scrotum

inguinal/femoral bulges

Palpation:

penis (tenderness/induration)

testes

epididymis

inguinal canal

femoral canal

cremasteric reflex

Auscultation:

scrotal mass.

Peripheral vasculature:

Inspection:

skin

nail beds

pigmentation

hair loss

Palpation:

pulses - radial, brachial, femoral, popliteal, post.tibial, dorsalis pedis

lymph nodes - epitrochlear, femoral (horizontal & vertical).

temperature (foot & legs)

Manual compression test

Retrograde filling (Trendelenburg) test

Arterial insufficiency test

Musculoskeletal:

ROM

hip

flex. 90/120

ext. 15

abd. 45

add. 30

int rot 40

ext rot 45

knee

flex. 130

ext. 0/15

ankle

plantar flex 45

dorsiflex 20

inversion 30

eversion 20

leg length

Neurological:
- dermatomes
  - L1
  - L2
  - L3
  - L4
  - L5
  - S1
- muscle strength
  - hip flexion
  - knee extension
  - ankle dorsiflexion
  - plantar flexion
- tendon relexes
  - patellar
  - Achilles
- plantar reflex

Rectal examination:
- Inspection
  - sacrococcygeal & perianal areas
- Palpation
  - sphincter tone
  - tenderness
  - indurat[illegible]
  - nodules
  - prostate
  - seminal vesicles

Mental status

- Appearance and behaviour:
  - level of consciousness
  - posture and motor behaviour
  - dress, grooming, personal hygiene
  - facial expression
  - affect
- Speech and language:
  - quantity
  - rate
  - volume
  - fluency
  - aphasia (prn)
- Mood
- Thought processes (logical, relevant, organised)
- Memory and attention:
  - orientation (time, place, person)
  - remote memory
  - recent memory
  - new learning ability
- Higher cognitive functions:
  - information and vocabulary (general & specialised knowledge)

APPENDIX D1

TECHNIKON NATAL

TECHNIKON NATAL CHIROPRACTIC DAY CLINIC.

REGIONAL EXAMINATION -- LUMBAR SPINE AND PELVIS.

PATIENT: ______________________________

FILE # : ______________ DATE: ______________

INTERN/RESIDENT: ______________________________

SUPERVISING CLINICIAN : ______________________________

STANDING :

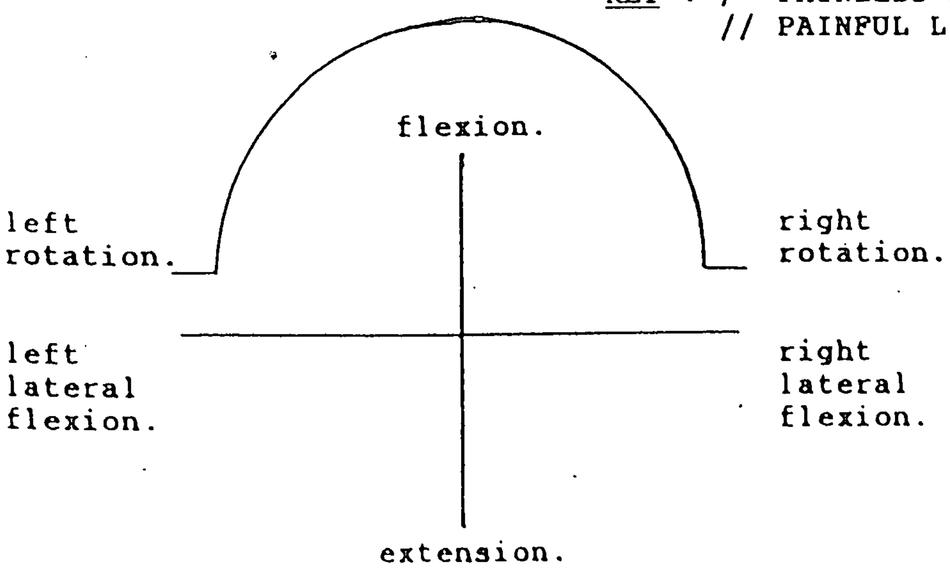
Posture
Minor's Sign
Skin
Scars
Discoloration
Muscle tone
Bony and soft tissue contours

Spinous percussion
Schober's Test (6cm)
Treadmill
Body Type
Attitude

RANGE OF MOTION.

Forward Flexion = 40-60 degrees.(15cm from floor)
Extension = 20-35 degrees.
L/R Rotation = 3-18 degrees.
L/R Lateral flexion = 15-20 degrees.

KEY : / PAINLESS LIMITATION.
// PAINFUL LIMITATION.



APPENDIX D2

SUPINE :

Skin.
Hair.
Nails.

SLR
Bowstring
Plantar reflex
Circumference (thigh, calf)
Leg length :
- actual
- apparent

Sciatic notch
Patrick Faber
Gaenslen's Test
Gluteus Maximus Stretch
Hip medial rotation
Psoas Test
Thomas' Test :
- hip joint
- rectus femoris

Observe abdomen
Fasciculations
Abdominal reflexes
Auscultate abdomen/groin
Palpate abdomen/groin
Pulses (abdomen)
Pulses (extremities)

LATERAL RECUMBENT :

S-I compression
Ober's Test
Femoral nerve stretch
Myotomes :
- QL
- Gluteus Medius

NON-ORGANIC SIGNS :

Pin Point Pain.
Axial Compression.
Trunk Rotation.
Burn's Bench Test.
Flip Test.
Hoover's Test.
Ankle Dorsiflexion Test.

PRONE :

Gluteal skyline
Skin rolling
Iliac crest compression
Facet joint challenge
S-I tenderness
Erichson's Test
Pheasant's Test
Myotomes :
- GluteusMaximus

Active MF Trigger Points:
- QL
- Glut. Med.
- Glut. Max.
- Glut. Min.
- Piriformis
- Hamstrings
- TFL

APPENDIX D3

GAIT :

Rhythm
On toes (standing)
On heels (standing)
Half-squat on one leg

Remarks :

NEUROLOGICAL EXAMINATION :

DERMATOMES:	Left	Right.
T12		
L1		
L2		
L3		
L4		
L5		
S1		
S2		
S3		

MYOTOMES:	Left	Right.
hip flex		
hip int rot		
hip ext rot		
hip abd		
hip add		
knee flex		
knee ext		
dorsiflex		
plantarflex		
eversion		
ext.hall.long		

REFLEXES:	Left	Right
C5		
C6		
C7		

Tripod
Kemp's Test

COMMENTS:

APPENDIX D4

MOTION PALPATION :

Jt.play		Left						Right					Jt.pla	
/A	Lat	Fle	Ext	LF	AR	PR		Fle	Ext	LF	AR	PR	P/A	Lat
							T10							
							T11							
							T12							
							L1							
							L2							
							L3							
							L4							
							L5							
					U	L	SI	U	L					

APPENDIX E1

TECHNICAL DESCRIPTION OF DATA ACQUISTION DEVICE

Designed and built by the Department of Electronic Engineering, Technikon Natal

A pentium '90 processor was used with in conjunction with a Intelligent Instrumentation data acquistion board (PCI 20450P-10). An amplifier was also designed to provide the correct levels of signals. The signals were sampled via analogue to digital converter at a frequency of 12.5 kHz therefore allowing frequencies up to 6.25 kHz. to be measured.

The software was written with a Visual Designer package implementing fourth generation block programming.

The spectrum frequency of the cavition sound was found to be in the region of 250-750 Hz. Above this region the signal to noise ratio was found to be quite high. Therefore this spectrum of frequency was used.

Fast Fourier Transforms (FFT) were used to convert the input signals to a frequency spectrum. The frequency spectrum at 250-750 Hz. was filtered using the FFT. and convolution at the magnitude appropriate to the spectrum. This was done with the following method. The FFT buffer size was calculated at being at 512 samples. Transferring this into time domain at 1024 time domain samples.

If the magnitude of the FFT is considered. The total time therefore that the signals were sampled at was : 1024 x 1/12500 seconds.

Therefore the range of frequencies required at each point of the FFT transform correspond to an increment of :6250/512 =12.207 Hz. per second per point.

The signal was located at 250 -750 Hz. of the spectrum therefore the 20-62 FF. points in the series. Only these points were considered. The power spectrum of these signals were considered which is calculated as the square of the 20 -62 FFT. spectrum.

The total components of the spectrum were integrated and the spectrum integrals of the of the 8-channels were compared. The highest value was selected as the channel where the cavitation/s originated.

NOTE: SEE OVERLEAF FOR CIRCUIT DESCRIPTION AND CONSTRUCTION

LECTROKIT

MICROPHONE PRE AMPLIFIER
(KIT No: 123)

CIRCUIT DESCRIPTION

The LM358 consists of two independent, high gain, internally frequency compensated operational amplifiers which are designed specifically to operate from a single power supply over a wide range of voltages. The microphone input is decoupled by C1, R1 and R4 set a fixed gain for the first stage. R2 and 3 act as a voltage divider biasing the non inverting input Pin 3 to half the supply voltage. The output of the first stage Pin 1 is coupled to the non inverting input of the second stage Pin 5. The second stage gain is set by RV1. The output is AC coupled to the output by C3. Fig 1 is the circuit diagram of the microphone pre amplifier.

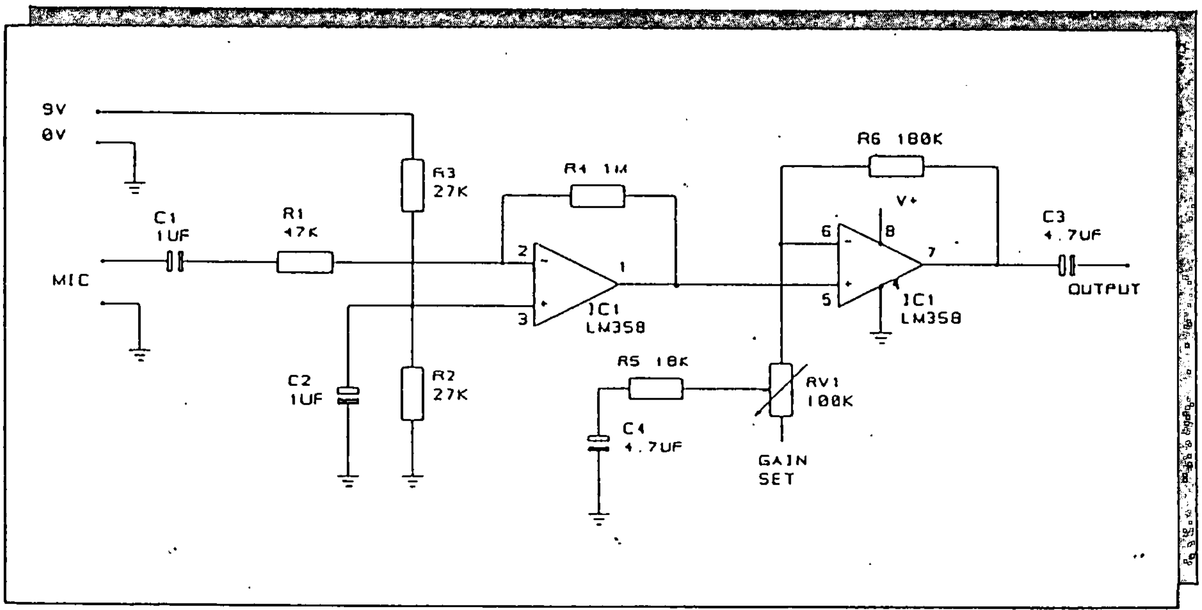


Fig 1: CIRCUIT DIAGRAM

USES

Uses include simple microphone amplification circuits for eg: Tape recorders, Intercoms, PA Systems, and Tape Deck Radios.

CONSTRUCTION

The PCB is assembled by carefully following the component overlay and inserting the components into the correct locations as indicated in Fig 2. Observe the polarity of the electrolytic capacitors in construction. Connect the microphone and power leads to the indicated locations (9 to 12V may be used).

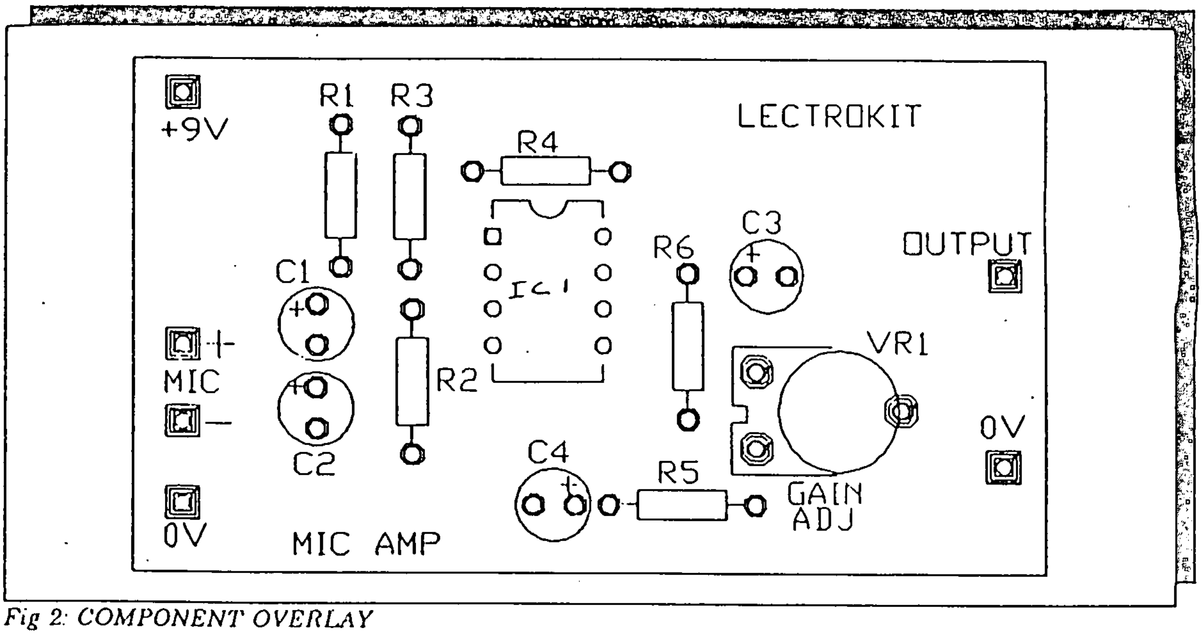


Fig 2: COMPONENT OVERLAY

PARTS LIST

RESISTORS

R1	47K
R2	27K
R3	27K
R4	1M
R5	1K8
R6	180K
RV1	100K

CAPACITORS

C1	1uF/16V
C2	4.7uF/25V
C3	4.7uF/25V
C4	4.7uF/25V

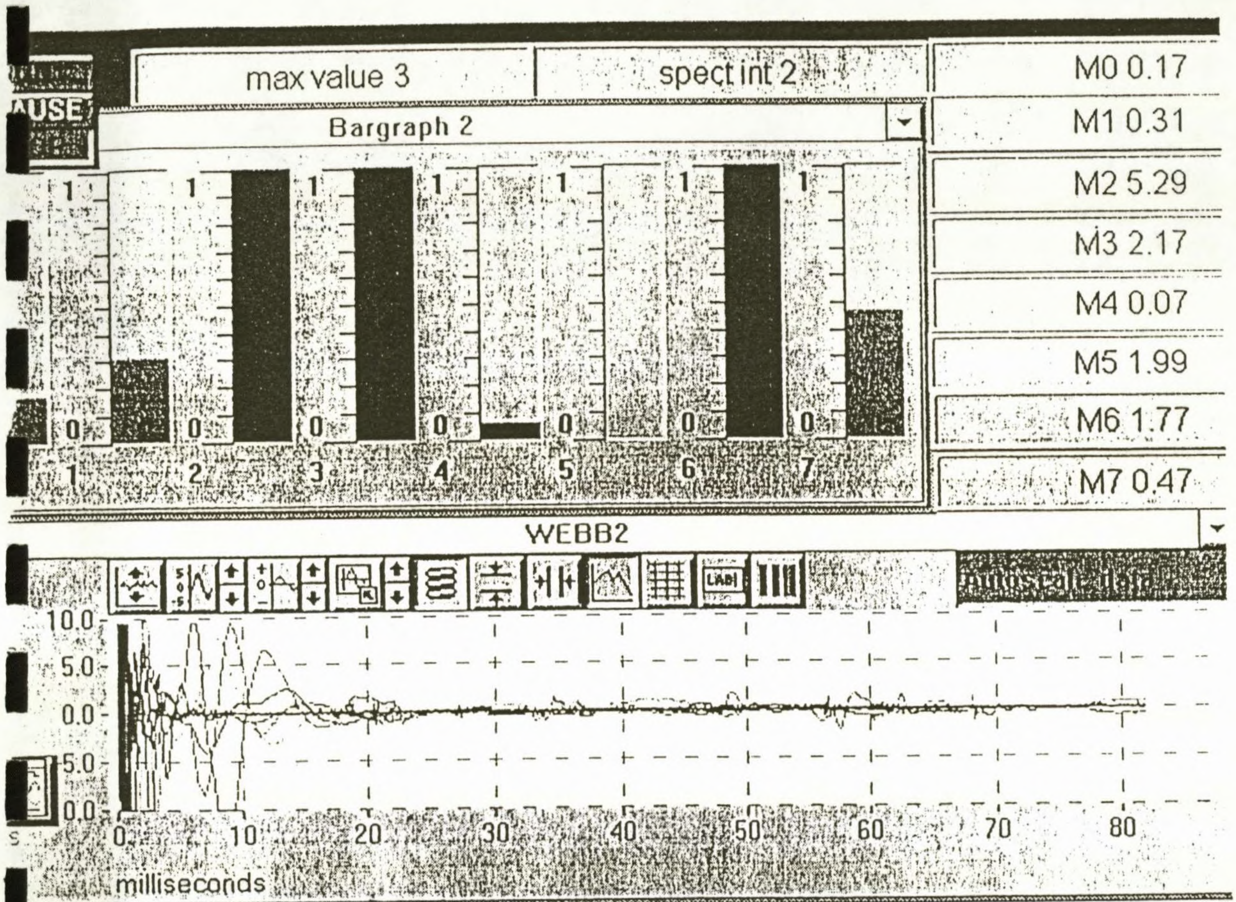
SEMICONDUCTORS

IC1	LM358

MISCELLANEOUS
PCB
MICROPHONE (Not supplied)

APPENDIX F

SAMPLE OF A READ-OUT FROM THE DEVICE



APPENDIX G

THE LIMITATIONS OF THIS METHOD

A report by the Department of Electronic Engineering, Technikon Natal on limitations of the methodology of this research.

- The amplitude of certain signals were above the amplifier and the data aquisition board range. This caused clipping of the signals and could be the cause for some errors.

- The sound could propogate more through different types of tissue and bone therefore the amplitude method could cause some errors.

- The microphones did pick up some noise with movement of the person. This was the main cause of false triggering.