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The Chiropractic adjustment as the treatment of choice by Chiropractors

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Narrative: The idea of subluxation has strong clinical relevance within the practice of Chiropractic, being integral to some 80% of the profession globally and is overt in more than 1,600 peer-reviewed, indexed Case Reports.

History records the founder of the discipline, DD Palmer, as naming the unique psychomotor skills that he developed to, as he said '*move the vertebrae of the spinal column*', the 'adjustment'. These skills were taught by him at the Palmer School of Chiropractic and are now used by nearly all Chiropractors globally. The skills required to safely deliver the adjustment are a mandatory attainment in every curriculum. The purpose is to restore health and well-being.

A variety of techniques can be applied to correct subluxation and when these meet certain criteria, given here, for applied force and speed of force application, then the therapeutic intervention is known as a Chiropractic adjustment.

To conclude, I present Haavik et al's contemporary model of the mechanism by which central segmental motor control (CSMC) problems and spinal adjustments result in neuroplastic consequences that impact neuromuscular function.

Indexing Terms: chiropractic; subluxation; adjustment; manipulation'; central segmental motor control (CSMC).

Introduction

'*The arbiter and ultimate test between the Chiropractic spinal adjustment and spinal manipulation is the central segmental motor control changes that occur as sequela to that treatment*'.

Mark Studin
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in: Dynamic Chiropractic, 2024

The term adjustment is central to the identity of Chiropractic and was included by the founders of Chiropractic, DD and BJ Palmer, in the title of their first joint textbook The Science of Chiropractic - Its Principles and Adjustments. (1) My colleague Donald McDowall explains that the term 'adjustment' originated with Palmer the Founder, citing him from 1904:

> *... The Chiropractic adjustment is the highest order skill-set on the spectrum of mobilisation and manipulation.It is incorrect to refer to the adjustment as 'manipulation; ...'*

> 'In my practice of the first ten years I followed a line of thought; that thought was that diseases were caused by a difference in the patient affected and the one not

so. By my treatment of the effects, previous to this, I was continually coming closer, and on Jan. 14th, 1896, I was pleased to name that science "chiropractic". The unique movements that I developed to move the vertebrae of the spinal column, that are now used by all chiropractors, and are now taught at the Palmer School of Chiropractic, I named "adjustment"'. (2)

The spinal adjustment as delivered by trained Chiropractors is the highest order skill-set on the spectrum of manipulation and is primarily but not exclusively a therapeutic intervention for spinal segments and the pelvis. Chiropractic as a clinical discipline is characterised by the optimally controlled high-velocity, low-amplitude thrust which is now known to stimulate clinically significant neurological benefits not seen with generic manipulation. (3)

In this chapter I will report the latest definition of manipulation and show how it still falls short of explaining the adjustment. Worse, its authors consider that intent is irrelevant while I hold that intent is paramount, first to assign a high degree of finesse to both the vectors and the forces applied, and second for the reason any thrust into a person must address an identified lesion with therapeutic intent or be considered assault.

I include an overview of the forces involved at the spine and the techniques for achieving optimal biomechanical integrity in the psychokinematic chain and report findings from discipline's literature.

Spinal adjustment refers to the application of predictable forces at a predictable velocity applied by hand or mechanical devices with the intent to correct a perceived biomechanical dysfunction embodied within a Vertebral Subluxation Complex. It is known to be associated with a neurophysiological cascade. Like all clinical skills it is learned and is improved with practice and reflection on how to improve.

In this paper I use 'speed' and 'velocity' interchangeably, appreciating that speed is a scalar quantity that measures how fast an object is moving, defined as d/t (the distance traveled over time). In contrast, velocity is a vector quantity that includes both the speed of the object and its direction of movement, represented by an arrow, for example →. The adjustive thrust is more correctly considered as a 3-Dimensional vector with a specific product to create the correction, but the human mind thinks more in term of 'how fast' was that thrust. I'm happy to talk of 'speed' measured in milliseconds (ms) for an event from start to finish.

The manipulation spectrum

Within the context of health care, manipulation is a generic term descriptive of manual intervention. Manipulation includes a range of learned skills that begin at a basic level with manual treatment such as massage and specific muscle and soft tissue techniques as seen, for example, within myotherapy. Beyond this lies a range of techniques collectively considered as mobilisation, a passive movement by the clinician of a joint or number of joints in the patient, usually by means of long levers.

Mobilisation movements remain within the elastic barriers of the joint or joints and are generally repetitive and rhythmic. They may include stretching into the elastic barrier and their collective purpose is to reduce soft tissue adhesions about a joint complex that may be restricting its movement with a view to increasing the joint's range of motion and improving general mobility.

The skill levels increase within the field of mobilisation and may lead to a range of techniques considered as 'mobilisation with impulse'. These are common to some branches of osteopathic practice (4) and physical therapy. (5, 6) Depending on the duration of the pre-impulse mobilisation period and due to the crudeness and perhaps lack of specificity of the impulse these may also be largely considered as the manipulative tool-kit used by non-chiropractors such as medical manipulators. (7, 8, 9, 10) These are the types of techniques commonly referred to collectively as 'spinal manipulation' and are the technique referred to by David Evans, the most prolific current author in the field.

Evans is well aware of Chiropractic as the discipline, (11) but not so much about Chiropractic the philosophy. His Chiropractic collaborators have included Kenneth Young and Charlotte Leboeuf-Yde, (12) both being deniers of the subluxation premise. Their joint paper on Mechanisms of manipulation concluded '*It is a common clinical observation that patients can experience sudden relief immediately after SM. In our experience, when this happens, they may ask: "What exactly happened when you cracked my back?*" As this review describes, there is no easy answer because of the many theories and few facts'.

The limitation of that review is its mechanical focus to the exclusion of neurophysiology, reflecting the bone-setter shallowness of European Chiropractic. They recommend that therapists who apply spinal manipulation explain their actions to the patient as

> 'Regarding anatomical/positional changes, it would be possible to say: "There is no simple answer, because the spine is a difficult area to study. It seems likely that the manipulation/adjustment causes some physical changes, but it is not known exactly how. Presently, though, we are fairly confident that the facets, i.e., the small joints at the back of the spine, open up a little bit. There also seems to be a measurable change in the stiffness of the spine immediately after manipulation. We assume that these changes are part of what helps you feel better".' (12)

Remember, this feeble explanation is completely devoid of the neurophysiological effects and and the flow-on to neuroplasticity and was mostly authored by academics calling themselves a chiropractor while holding the European bone-setter mindset, rejecting the Palmerian model.

Since 2010 Evans, who is not a chiropractor of any variant but an osteopath (13) of the British school of osteopathic thought which differs significantly to American osteopathy, has been developing a definition of manipulation, starting with a reappraisal (14) and culminating over a decade later (15) with this position on manipulation:

> 'Separation (gapping) of opposing articular surfaces of a synovial joint, caused by a force applied perpendicularly to those articular surfaces, that results in cavitation within the synovial fluid of that joint'. The corresponding definition for the mechanical response of a manipulation is: 'Separation (gapping) of opposing articular surfaces of a synovial joint that results in cavitation within the synovial fluid of that joint'. In turn, the action of a manipulation can be defined as: 'A force applied perpendicularly to the articular surfaces'.

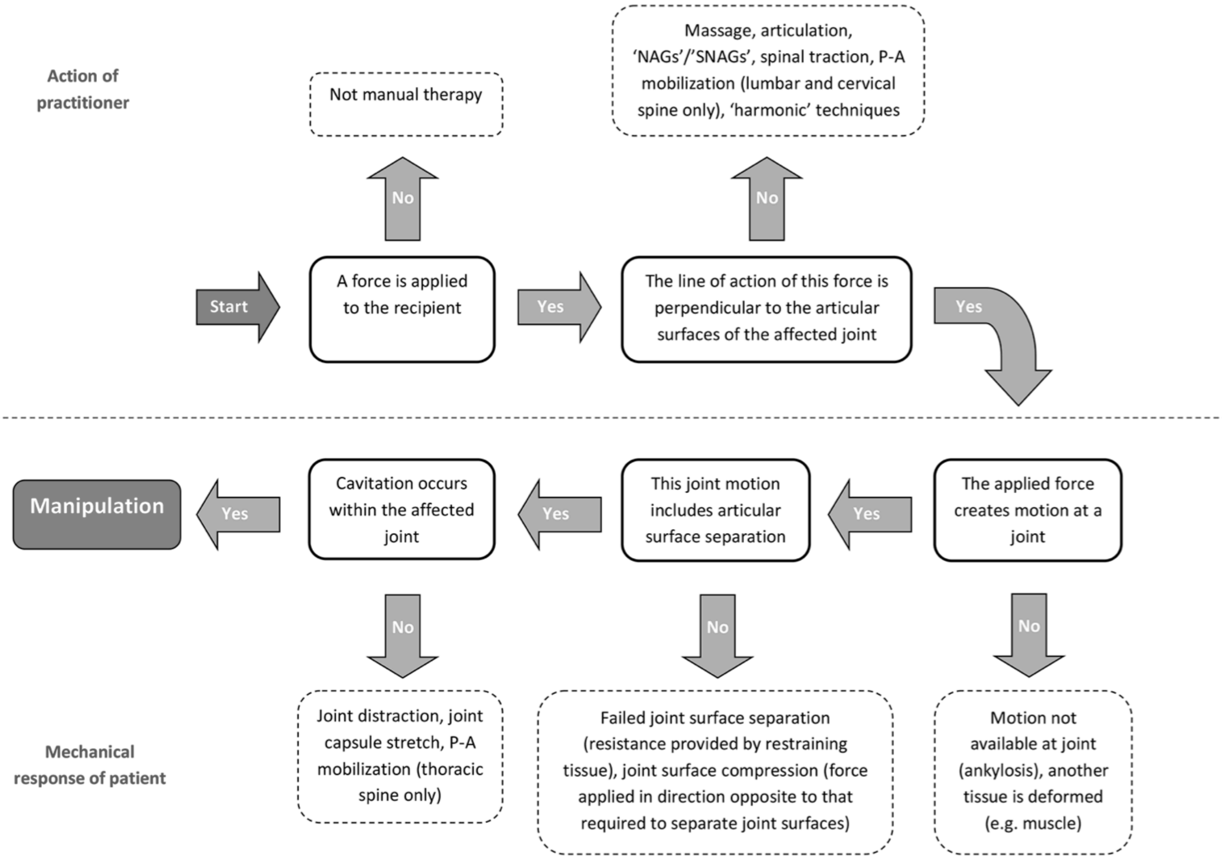
Along the way Evans questioned the entrenched belief that a paraphysiological space exists within a diarthrodial or synovial joint including about the spinal mobility unit and concluded, (16) as have myself (17) and Rome and Waterhouse (18) that the belief is flawed. Even though he has written with some European chiropractors, Evans firmly takes the position of an osteopath, as shown in his '*modern way to teach and practice manual therapy*'. (19)

Nevertheless, his causal pathway relating the necessary features of manipulation which underpins both his 2010 and 2023 papers is useful for understanding the manipulation pathway as he sees it. While it stops short of including the Chiropractic adjustment, I give it as Figure 1 as it, together with his new definition of manipulation, clearly shows it is relevant only to the beliefs of manual therapists. I contend that fully-trained Chiropractors function at a higher level.

What is notable is that Evans places clinical importance on achieving cavitation, a topic minimised in conversation by those who call themselves chiropractors while lacking the skills to deliver the adjustment with cavitation when it is indicated. Note also that the end-point of Evans' pathway is termed the 'mechanical response of patient' and this is the clear point of departure for the Chiropractic adjustment from his generic manipulation.

I will now show the higher level of outcomes considered as neurophysiological responses and altered neuroplasticity associated with the well-performed Chiropractic adjustment when directed at an identified or target lesion, most commonly the subluxation within a VSC.

Figure 1: Causal pathway relating the necessary features of manipulation. (15)



Characteristics of the adjustment

One of the earliest reports was by Dan Dishman (20) who reviewed the literature and reported a scientific basis for the Chiropractic subluxation complex. He reported strong evidence for both the mechanical model of disease production (structural) and the neurobiological model (functional). It is the neurobiological model which is now ascendant, however in 1988 Dishman seemed to favour the mechanical model. (21)

He wrote '*a subluxation may be considered as being fixated and also slightly malpositioned in one or more axes of rotation. Subluxation may be considered as one component of a complex or syndrome of intervertebral dyskinesia, dysarthrosis or dysfunction. The biochemical and histological components explain some of the pain mechanisms, tissue changes and residual effects of acute and chronic intervertebral fixation and the need for repeated spinal manipulations and prolonged care. Interexaminer reliability studies indicate that a standard method of motion palpation is quite feasible and accurate. X-ray evidence of dyskinesia shows promise as a means of documenting subluxation fixations*'.

It was 20 years before further meaningful research appeared in the literature and I refer to Pickar's report of his electromyographic study in 2005. (22) He reported that manipulation induced a virtually immediate change, usually a reduction, in resting EMG levels in at least some patients with low back pain and tight paraspinal muscle bundles. In some cases, EMG activity increased during the treatment protocol and then usually, but not always, decreased to a level lower than the pretreatment level.

The following year Pickar reported that his research findings suggested that one biomechanical characteristic of an HVLA-SM was its capacity to load paraspinal muscle spindles at a rate where their velocity sensitivity predominates over their length sensitivity. (23)

By 2011 attention had returned to the mechanics, in particular the notion of joint cavitation. Cramer led a team to investigate this and found that '*Eight joints cavitated more than once. Group 1 joints cavitated more than group 2 joints (P < .0001), upside joints cavitated more than downside joints (P < .0001), and joints inside the target area cavitated more than those outside the target area (P < .01)*'. (24)

Cramer placed accelerometers over lumbar spinous processes and sacral tubules and on each side at the interspinous space of L4/L5. Group 1 were measured during positioning and adjustment, and Group 2 with adjustment only. I think the results show that cavitation occurs, may occur during patient positioning, and is likely to occur beyond the target spinal level. Nevertheless, cavitation is a real clinical phenomenon.

The following year Cramer went further to quantify cavitation and gapping of lumbar zygapophyseal joints during spinal manipulative therapy (25) and concluded that '*Zygapophyseal joints receiving chiropractic SMT gapped more than those receiving SPP alone; Z joints of men gapped more than those of women, and cavitation indicated that a joint had gapped but not how much a joint had gapped*'. This is the first evidence that cavitation was associated with the physical effect of adjusting the spinal Z joints.

In 2013 it was reported that relatively low-amplitude thrust displacements applied during an HVLA-SM produced sustained increases in the resting discharge of paraspinal muscle spindles regardless of the duration over which the thrust was applied. However, regardless of the HVLA-SM's thrust amplitude or duration, the responsiveness of paraspinal muscle spindles to vertebral movement and to a new vertebral position was not affected. (26)

Also in 2013 Cramer reported further investigation to quantify his earlier reported 'gapping' phenomenon. (27) He found '*Gapping differences were significant at the first (adjusted, P = .009; SPP, 0.66 ± 0.48 mm; SMT, 0.23 ± 0.86; control, 0.18 ± 0.71) and second (adjusted, P = .0005; SPP, 0.65 ± 0.92 mm; SMT, 0.89 ± 0.71; control, 0.35 ± 0.32) MRI appointments*'. (27)

Cramer went further to associate these mechanical changes with patient-reported clinical changes, '*Verbal numeric pain rating scale differences were significant at first MRI appointment (P = .04) with SMT showing the greatest improvement. Visual analog scale and Bournemouth questionnaire improved after 2 weeks of care in all groups (both P < .0001)*'. (27)

Pickar returned the following year, 2014, (28) to '*examine the effect of HVLA-SM thrust duration on nociceptive-specific (NS) lateral thalamic mechanical response thresholds.*' He reported that '*High-velocity, low-amplitude spinal manipulation duration did not significantly alter NS lateral thalamic neurons' mechanical trunk responses to any of the 3 directions tested with the anesthesiometer*.' (28)

This seems to be about the last word on the mechanical effects of, as they called it for political reasons, 'spinal manipulation'; I hold that given the thrusts were delivered by experienced Chiropractors in a Chiropractic research environment, it is fair to consider the above as reports on the Chiropractic adjustment.

Thankfully, earlier in 1997 Fred Carrick announced the results of his investigation into changes in brain function after manipulation of the cervical spine. (29) Among other things Carrick found that 'Manipulation of the cervical spine on the side of an enlarged cortical map is associated with increased contralateral cortical activity with strong statistical significance (p < .001)'. He concluded:

> 'Accurate reproducible maps of cortical responses can be used to measure the neurological consequences of spinal joint manipulation. Cervical manipulation activates specific neurological pathways. Manipulation of the cervical spine may be associated with an increase or a decrease in brain function depending upon the side of the manipulation and the cortical hemisphericity of a patient'. (29)

Carrick's work was a major turning point in terms of theories of mechanisms associated with the Chiropractic adjustment. BJ Palmer's work in this field in the 1930s went nowhere as he did not publish in the scientific literature, which is understandable given the rudimentary nature of the literature at that time. His device was called the Electroencephaloneuromentimpograph. (30) At 34 letters it is surely the longest word in the discipline of Chiropractic. I give an image of a patient being measured by the instrument as Figure 2.

Figure 2: Bartlett Palmer with a patient undergoing measurement by the Electroencephaloneuromentimpograph.

The Electroencephaloneuromentimpograph instrument was designed to measure 'minute degrees of mental impulses' and was housed in a heavily shielded room to isolate it from extraneous electromagnetic fields. It took inputs from five places:

- at the source, the brain
- at the subluxation
- at the point where nerve emits from the spine below subluxation
- at any point between periphery and spinal exit, and
- at the periphery.

Perhaps something did arise from this work, the focus on upper cervical adjusting. Coming back to Carrick's paper of 1997 it is fair to say Carrick's report drew much comment as there are a dozen letters indexed on the topic.

Earlier, in 1993, Terrett published a theory '*to explain a possible mode of action of spinal manipulation in some patients with complaints that are extremely difficult to quantify, such as visual disorders, dizziness, depression, anxiety, memory problems, attention span problems, difficulty with concentration, irritability, tiredness, and clumsiness*'. (31) He published with the intent to '*generate comments from the chiropractic profession, and to develop a study to test the theory*'.

About the same time Frank Gorman was using perimetry to measure changes in the field of vision which may have an association with upper cervical adjusting. (32) He reported '*that spinal manipulation may dissipate microvascular spasm in the brain: even in branches of the carotid arterial* *system, which is not directly related to the spine. The author feels that the underlying pathology was interictal migraine, which is now known to produce prolonged hypertonic changes in the cerebral microcirculation; and he suggests that spinal manipulation is a treatment to be considered for interictal migraine*'.

From the mid-1990s and especially from Carrick's paper, a stream of investigation was undertaken into the neurophysiological effects of the adjustment, culminating in the focus on neuroplasticity. However some reports are speculative and one adds nothing, as to be expected from Leboeuf-Yde, and is rather facetious and negative. (33) Gil Weiner produced a delightful paper provoking these mechanists and showing that we have entered the era of 'simple, elegant complexity' in terms of understanding the effects of the adjustment. (34) He is not impressed with their perpetuation of the 'foot on a hosepipe' myth.

What we do have that is meaningful are case reports exploring the clinical effects associated with the correction by adjustment of the VSC on matters such as anxiety and suicidal ideation (35) and improved reading and academic performance in dyslexic students. (36)

Contraindications

Any discussion on the adjustment must make note of the contraindications to its use. I summarise these in Box 1 using the mnemonic VINDICATES.

Box 1: Contraindications and cautions to Chiropractic adjustment

Using the mnemonic VINDICATES

V	vascular (ischaemia, dissection, aneurysm, claudication)
	clotting disorders (haemophilia or anti coagulant therapy users)
I	infection (such as osteomyelitis); inflammation (acute, chronic or recurrent)
N	neoplasia (benign, primary malignant or metastatic of the region to be adjusted; metastatic spread to the spine)
	neurological (brain, brainstem, cerebellum, spinal cord, peripheral nervous system; frank disk herniation or disruption with neurologic signs)
D	degeneration (arthritic, bone weakening, bone softening, loss of anatomical integrity of joints)
I	idiopathic, iatrogenic
C	congenital (including upper cervical instability with anomalies such as hypoplasia of the dens)
A	arthritide (rheumatoid, ankylosing, psoriatic, osteoarthritis)
T	trauma to bone, cartilage, connective tissue, muscle, vascular system, viscera
	toxic reaction (to pharmaceutical drugs, complementary and alternative medicine products, environmental poisons)
E	endocrine or metabolic
S	sociological (non-cooperative or non-compliant patient, a patient who does not consent to care, malingering)

The preceding has been a short journey through the history of how the understanding of the effects associated with the Chiropractic adjustment have emerged and developed over time. We can be very sure of our ground now thanks to Haavik and her research team at the New Zealand College of Chiropractic. Their Centre for Chiropractic Research is a world-class research facility driven by dedicated researchers who are leaders in neurophysiological research. Apart from their work with neuroplasticity, their neuromuscular findings are also notable. (3)

> The rapidly developing evidence for neuroplastic and neuromuscular effects represents the neurophysiological paradigm of the adjustment and is a significant advancement on the mechanistic approach pursued by Evans and Leboeuf-Yde.

With this understanding we can now examine the nature of the Chiropractic adjustment in the neurophysiological context.

The safe, clinically effective adjustment

Skilled spinal adjustment by fully-trained and experienced Chiropractors is an extremely safe clinical intervention yet as with all therapeutic interventions there are risks, cautions and contraindications that must be explored by an appropriate and thorough clinical history and examination of the patient. Any decision to include adjustment within the patient's management plan must be supported by sound clinical evidence. I have identified and categorised the minimal required evidence in my new textbook The Chiropractic Subluxation. (XLibris, from early 2026) This paper is a chapter from that textbook.

> In pragmatic terms the spinal adjustment is a biomechanical means of creating a neurophysiological response with neuroplastic effects within the brain and about the spinal column. It is a conservative intervention and is only indicated following a specialised examination and diagnosis of the patient and may be supported by other manual treatments, exercise and patient education.

Depending on the spinal level, the adjustment delivers forces of around 104 N (cervical spine), 506 to 554 N (mid and low thoracic spine) and 225 N (sacroiliac joint) within about 90 ms (cervical spine), up to 150 ms (thoracic spine) and between 166 and 182 ms (sacroiliac joint). These variables do not differ significantly between male and female Chiropractors.

It is said that the toggle adjustment is the fastest manual Chiropractic intervention. I have personally timed the delivery of such a thrust delivered by an expert in the field, Dr Neil J Davies, and consistently found the thrust to be well under 30 ms, at times closer to 20 ms. Part of the explanation for the attainment of such high velocity is the involvement of the pectoral muscles in the thrust. The pectoralis major has a high proportion of fast-twitch fibres, particularly Type IIx, which are known for their rapid contraction speed. These fibres can reach maximum tension in about 7.3 milliseconds, making them ideal for explosive actions like pushing, throwing, and 'toggling'. By the time this impulse engages the full psychokinematic chain to produce the toggle adjustment, 20 to 30 ms is understandable. Mind you, this level of performance demands extensive practice and daily exercises.

The reason why high velocity is the critical element in the Chiropractic adjustment is that its speed must be faster that the reaction time of the supportive musculature about the joint. We currently know little in detail about this by each spinal region, but in broad and generic terms, muscles about the spine are though to respond to a mechanical stimulus in 200 to 250 ms. There are many factors involved and it is quite difficult, technically, to actually measure. We do know that athletes in their peak have reaction times under 200 ms, but 'reaction time' necessarily includes visual and audio stimuli.

> My general rule of thumb is that any adjustment into the spine that is slower than the reaction time of the supportive musculature about the segment being adjusted will be painful and perhaps damaging as the force of the thrust is applied to actively contracting muscle to form a protective defence. The times given in the literature for an adjustment of 90 ms in the cervical

spine, up to 150 ms in the thoracic spine, and between 166 and 182 ms for the lumbar spine and pelvis, seem to be well under the notional 200 ms reaction time of muscle, and thus in a 'safe' zone.

The technical dimensions

The adjustment has always been seen as the highest-order psychomotor skill-set within the spectrum of manipulation. This level of skill is demanded for the safe and effective delivery of the spinal adjustment. Since the first chiropractic technique books were written in the early 1900s (1, 37, 38) the discipline has consistently emphasised a unique skill-set centring around high-velocity, low-amplitude thrusts (HVLA), with or without recoil (39 - 54).

However it has only been since the late 1980s (55) that laboratory equipment has been available with sufficient sensitivity and specificity to allow quantification of the outcomes of the psychomotor skill set used by Chiropractors. (56) It is even more recently that enough theoretical reasons have been identified to propose that for mobilisation and HVLA 'manipulation' (the adjustment) be considered as separate clinical entities. (13)

> Bolton and Budgell (57) hypothesised that mobilisation techniques most likely affect the more superficial axial muscles, while HVLA 'manipulation' techniques, otherwise termed the adjustment, may particularly stimulate receptors within the deep intervertebral muscles and thus achieve different therapeutic effects. Whilst acknowledging a range of mechanical effects associated with the adjustment, Bolton and Budgell (56) proposed that the adjustment influenced different neurosensory beds than the slower, more general mobilisation techniques.

It is important to appreciate a philosophy within Chiropractic that provides a context for the science discussed in this chapter. In particular, the traditional viewpoint is that the difference between adjustment and manipulation is one of intent. I appreciate that Evans (13, 14) dismisses this but then his view is limited to that of a mechanist and therapist in a philosophical void. Conversely some Chiropractors go further and consider themselves as 'straight chiropractors' and see the adjustment of the vertebral column not as a treatment for musculoskeletal disorders or somatovisceral diseases, but for the purpose of allowing a vitalistic phenomena within the organism to be more fully expressed. (58) These are the concepts originated by the founder of chiropractic, DD Palmer and his son Bartlett. (1)

Straight Chiropractors contend that the technique or procedure is of little relevance; that it is the intent or objective of the practitioner that is important. One unfortunate result of this mindset is a diminished need for any text which attempts to categorise and describe a range of techniques from which the Chiropractor may select those most suited to an individual patient and their particular clinical presentation. Seeing only nails means they only need a hammer.

Another unfortunate outcome is that any intent to adjust the spine purely to allow a greater expression of vitalistic phenomena within the organism represents dogma and is an unsustainable position. (59) Mirtz likens this to theology. Over time this has led some critics of Chiropractic to see the discipline as perhaps cultist instead of as it really is, a patient-centred and biopsychosocial approach, emphasising personal responsibility for health, self-care and the self-healing powers of the body and having a model of health encouraging patient independence. (60) This 'patient-centred' approach has long been recognised as an attribute of Chiropractic practice. (61, 62, 63, 64, 65)

Today's Chiropractor is a conservative spinal care expert or specialist whose expertise is based on sound educational principles and evidence-based practice and research. This practical focus on the spine is set within a wholistic, patient-centred approach and is associated with whole body and whole-health outcomes. The discipline has grown and developed over more than a century to focus on neuromusculoskeletal disorders, particularly in the relationships between the spine and the nervous system and their effect on general health and well-being, and Quality of Life.

The adjustment paradox

Recognition that the spinal adjustment is associated with multidimensional intents ranging from the philosophical to the materialistic allows the development of valid research questions. The increasing flow of evidence addressing questions of the relationship between spinal adjustment and the nervous system and its effect on general health and quality of life is validating the adjustment as a legitimate therapeutic procedure. Further development of our knowledge of the biomechanics of the adjustment will allow the design and conduct of further clinical trials to explore the research questions and allow a better documentation of patient outcomes.

Notice I am associating the biomechanical nature of the adjustment with its known neurological sequela. Notwithstanding the fundamental principle of Chiropractic that subtle biomechanical derangements of the spine are the target of the spinal adjustment, there is little original research within the profession exploring this question. As recently as 2003 Wenban (66, 67) reported that only 6.3% of original research published in 7 leading Chiropractic scientific journals during the period 1990-1999 included the term subluxation in the title, abstract or index terms. He suggested the idea of the 'Chiropractic practitioner-scientist' was an oxymoron. (68)

The result is a 'massive theory-research-practice gap' (69) that leaves spinal adjustment as a largely empirical intervention, sorely in need of serious exploration and quantification, yet one that continues to enjoy increasing public demand and very high levels of patient satisfaction. (70, 71, 72, 73)

The matter of cavitation

Cavitation is a phenomenon that occurs within a joint cavity when the articular surfaces are rapidly separated within anatomical limits. Separation in this manner momentarily increases the volume of the joint thus decreasing its internal pressure. It is thought this allows gas to form within the synovial fluid, much the same as bubbles form in carbonated water (soda) when the lid of the bottle is removed, thus expanding the volume of that system and lowering its pressure. (74) Brodeur's conclusion is important for those who dismiss the importance of cavitation:

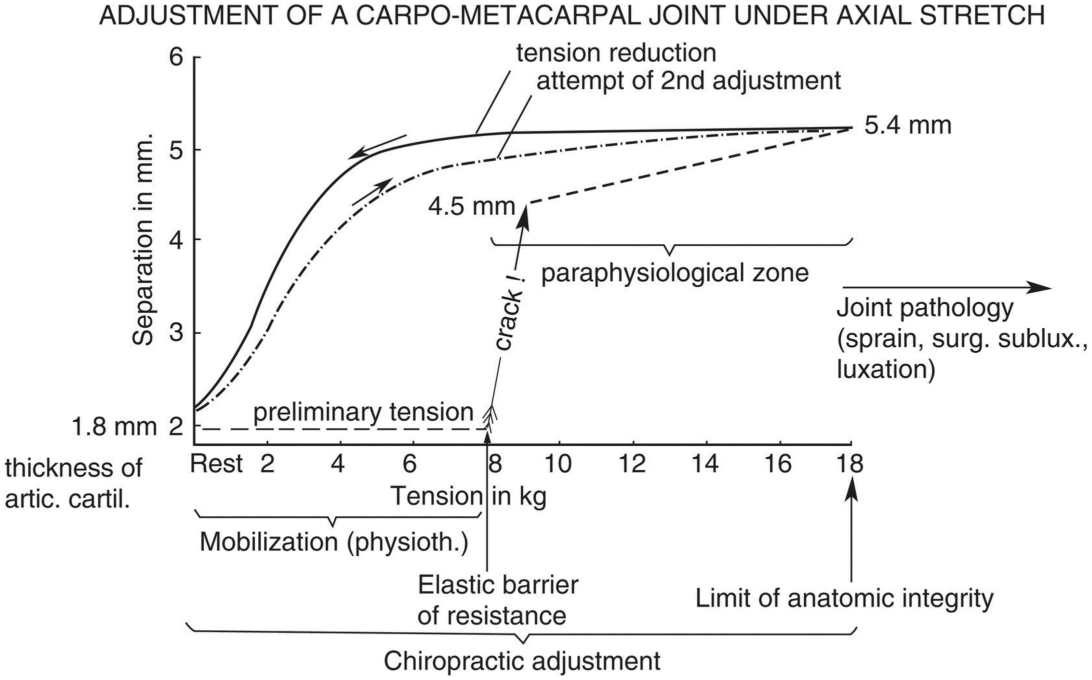
> 'without the cavitation process, it would be difficult to generate the forces in the appropriate tissue without causing muscular damage'.

The distraction of the finger provides the model and the graph given in Figure 3 has become somewhat of a classic demonstration of the finding that distraction of joint surfaces results in cavitation accompanied by an audible crack and followed by an increased resting separation between the joint surfaces. Further, there is a change in the movement characteristics of the joint when traction is applied after the joint has been cavitated. Vernon and Mrozek (75) identified 3 studies of finger distraction and note they have become part of the theoretical folklore of the Chiropractic profession. Common to the three studies is a refractory period of up to 30 minutes before the same joint can again be cavitated. (76)

A further finding, shown by the curved lines of the graph (Figure 3) is the change in motion that is evident following cavitation. It is known that the biomechanical behaviour of the joint under load (distraction in the case of the finger) exhibits different characteristics post-cavitation. It is presumed this change represents a clinical improvement in the joint's movement.

Most authors have accepted that the finger distraction model applies to the spine (77) however a critical investigation by Cascioli et al (76) found no evidence of gas in the joint space nor any obvious increase in zygapophyseal joint space width in the cervical spine immediately after manipulation.

Figure 3: Distraction of the finger producing a 'crack' from cavitation. (74)



They observed that their findings were not consistent with the current understanding of cavitation in joints. On the other hand, Cramer et al (27) found spinal adjusting produced increased separation of the zygapophyseal joints in the lumbar spine. The question of whether or not gas was present in the joint space following the adjustment was more challenging to answer. A further difference between the two studies is the significantly smaller size of the cervical z-joints compared to those in the lumbar spine and the attendant challenges associated with measuring change in such a smaller environment.

What is known about joint cavitation within the spine is that it may be documented using microphones (78, 79) and accelerometers (80, 81) and that the practitioner's perception of the occurrence of cavitation during the adjustment is accurate. (80) The question is whether cavitation belongs with the adjustment and this question remains open in the literature. (79) It may be that studies showing a relatively weak association between the target spinal joint and the source of the cavitation (78, 80) are more indicative of poor diagnostic procedures and the use of asymptomatic subjects than of the lack of any clinical relationship.

I appreciate that my citations above represent the early investigations of cavitation by Chiropractors, and acknowledge there have been some studies since, culminating in the latest by Williams and Gyer in 2024. (82) They did not undertake original research and instead reviewed the literature, concluding '*The priority of the clinician or therapist should not be to chase the "cavitation" nor to pursue the loudest "audible" possible, but rather to achieve effective post-intervention changes that are tangibly recorded during the post-assessment check*'. I disagree strongly and discount this paper given the authors are not Chiropractors, rather a 'functional movement clinician' (Williams) and an osteopath (Gyer). They lack both the neurophysiological and philosophical contexts.

My position raises the issue of my view being based on being a philosopher of Chiropractic, which gives me the need to better understand what it is that Chiropractors actually do which makes them very successful at what they do. I prefer to rely on the clinical wisdom of Rome and Waterhouse (83) whose skills as interpreters of the literature from all disciplines led them to conclude '*The biomechanical release of the articular fixation element of a vertebral subluxation is often signified by an audible cavitation. While some minor cavitation may occur with non-specific forms of finger manipulation, it has been shown that a manual adjustment results in audible cavitation which can activate sensory and autonomic reflexes*'. I find this last phrase highly important.

Rome and Waterhouse continue, '*more recent research indicates that the audible cracking sound is not related to the collapse of an intra-articular gas bubble*'. They conclude that '*the speed of the audible release and the cavity formation, the specific timing has yet to be conclusively demonstrated*'. (83) I agree with Rome and Waterhouse that there is more to the cavitation than we currently understand, especially as we are now determining that the speed of the adjustment seems related to the neurological effects which in turn are related to neuroplasticity. This question seems to be a demarkation point between manual therapists like Evans, previously cited, and Williams and Gyer, and I hold that the view of Chiropractors should be paramount. In summary, I propose:

> Audible cavitation is commonly associated with the Chiropractic adjustment and is suggestive of neurophysiological effects beyond the simple mechanical displacement, if any. It is acknowledged that when a synovial joint is tending towards being oedematous, the cavitation may not 'sound' as crisp or distinct.

A clinically accepted objective of a spinal adjustment is to rapidly separate the joint surfaces and provide proprioceptive input into the soft tissues surrounding the target joint. Given the anatomical and physiological similarities between the metacarpophalangeal and zygapophyseal joints as synovial joints, it is thought cavitation would typically accompany such a spinal adjustment.

In one of his early papers Evans (84) included a theoretical model (Figure 4) of the phenomenon of cavitation. The rather good model arose from his review of the literature on the mechanisms and effects of high-velocity, low-amplitude spinal thrusts. It shows how a bubble may form within the synovial fluid when joint surfaces are rapidly separated. When the bubble reaches maximum size it collapses into smaller bubbles which eventually dissolve back into the fluid.

Figure4: A representation of surface geometry and shapes of growing cavities within a synovial joint at a high separation speed as is likely to occur with high-velocity, low-amplitude adjustment. From Evans. (84)

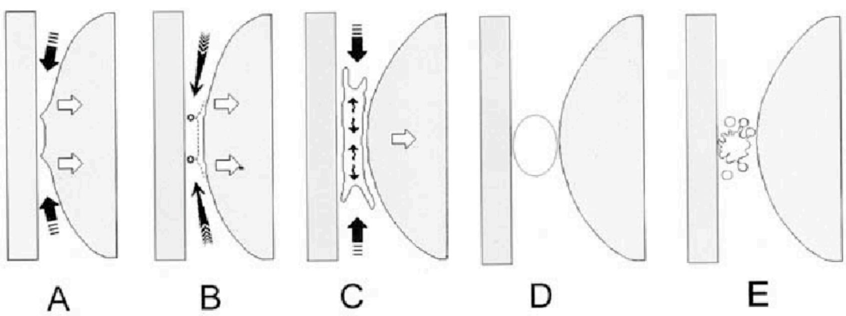


Figure 4 provides a representation of surface geometry and shapes of growing cavities within a synovial joint at a high separation speed as is likely to occur with high-velocity, low-amplitude adjustment. Toroidal (doughnut)-shaped cavities form around the contact zone. During separation the outer regions of the circular contact zone become pointed, A. The surfaces snap back at the circular rim where the cavity initially forms, B. The toroids coalesce into a single dendritic cavity that grows to become a bubble, C, and the newly formed spherical bubble reaches its maximum size D. Because it is unstable it collapses to form a cloud of many smaller bubbles, E, which later shrink as the gas and the vapour dissolve. The bubbles are demonstrated by radiography as a radiolucent region. (83)

This paper argues that cavitation to some degree should accompany the adjustive thrust however there is quite a window of variability dependent on the clinical state of the soft tissues around some joints, as with phases of inflammation resolution. It is also empirically noted that females of reproductive age may produce varying cavitation sounds during low back and pelvic adjustment and it is thought this may reflect hormonal, biochemical and fluid balance variation during the menstrual cycle.

It is known that fast treatment thrusts elicit muscle activation whereas slow force application does not. (85) This electromyographic (EMG) activity was observed consistently 50-100 ms after the onset of each of the fast thrusts whether or not the thrust resulted in an audible release. (85) The key element of the adjustive thrust within the spine would therefore seem to be high velocity and here it is typically the high velocity thrust that is associated with the rapid separation of joint surfaces that is in turn accompanied by cavitation sounds. This may not be so with long-axis distraction of the finger where even a slow application of load may eventually result in cavitation.

It must be stated that a range of mechanisms has been proposed (84) to explain the clinical outcomes of spinal adjustment including:

i. the release of entrapped synovial folds or plica
ii. relaxation of hypertonic muscles by sudden stretching
iii. disruption of articular or periarticular adhesions, and
iv. unbuckling of motion segments that have undergone disproportionate displacements.

It is not appropriate for this paper to explore these and other theoretical mechanisms and the reader is referred to Gatterman, (86) Haldeman, (87) and Leach. (88)

It is however appropriate to reinforce the concept that the adjustment is a mechanical means to impart neurophysiological effect. As a mechanical platform the adjustment will generate mechanical effects such as the release of entrapped synovial folds, but it is a gross simplification to try to understand the adjustment in purely mechanical terms.

It is especially an understatement to think of a vertebra as being a 'bone out of place', one of the early tenets of Chiropractic. (89) While it admittedly serves as a limited model to develop the necessary biomechanical skills that define the adjustment, the concept is clearly primitive in the face of our growing understanding of its neurological and physiological dimensions.

The target of the adjustment

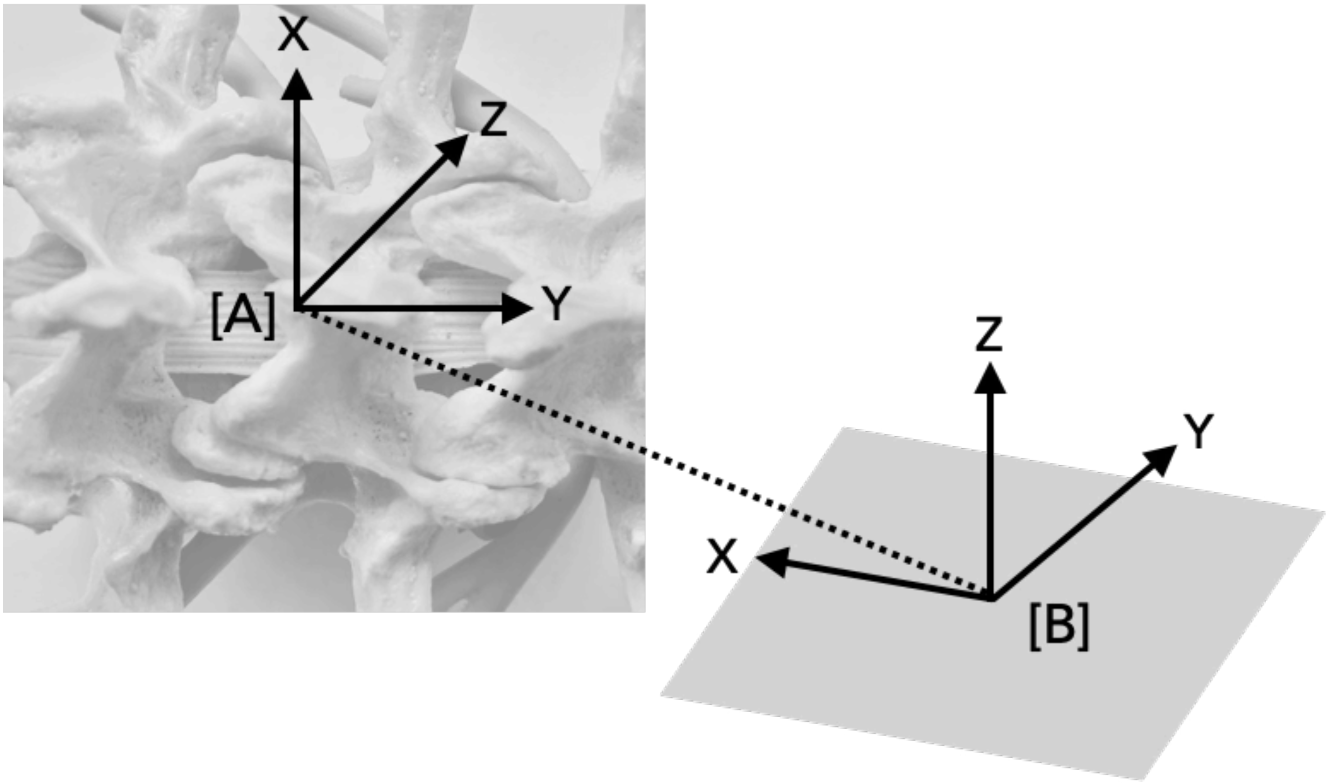
In broad terms the target of any adjustment is a specific joint or group of joints with reference to the 3-joint complex of the typical spinal mobility unit (SMU) typically but not exclusively synovial, (the SMU has 2 diarthrodial (synovial) facet joints with the disc as a fibrocartilaginous joint) where there are objective and subjective clinical findings of dysfunction to a varying degree. In specific terms the target of the spinal adjustment is a dysfunctional joint or joints within the spine or pelvis, typically within the SMU. Palmer first considered this problem to be 'misaligned vertebrae' which evolved through 'subluxed vertebra' to 'sub-luxation', and eventually, 'subluxation'.

Whether or not the adjustment cavitates the targeted joint is another question. A recent investigation into whether low back and pelvic adjustments cavitated the target joint concluded that neither an L5 pull-move nor a lower sacroiliac adjustment was associated with cavitation sounds from the targeted joint frequently enough to be statistically significant. (79)

It is also known that the application of high velocity forces into a spinal motion unit (SMU) produces coupled movements that are dependent on the magnitude of the applied force and the location of the contact point. (90, 91) This suggests cavitation may not always occur in the target joint but instead in other closely related joints. The coupled nature of the forces applied during adjustment are shown in Figure 5. This image, taken from the work of Triano et al (92) represents the 3 force vectors as they were applied to an estimated location of an L5/S1 disk centre in an experimental setup that measured the development of skill in delivering spinal manipulation. Figure 10.5 shows how these pure vectors result in clinical movements within the SMU.

The literature (79, 81) suggests it is questionable whether Chiropractors can actually target the adjustment to a specific segment, however these studies must be read with caution. The methodology of Beffa and Mathews (79) for placing the microphones around the low back was good and their findings are defendable technically which raises a series of questions about the adjustive techniques chosen and the competence of the clinicians who delivered the adjustment. McGill et al (81) used 28 different clinicians with experience ranging from 1y to 43y and applied a thrust to some area of the spine of asymptomatic subjects. Beffa and Mathews (79) also used asymptomatic subjects and fail to state the experience or training of the clinician who delivered the thrusts.

Figure5: Distribution of forces during a typical L5/S1 adjustment. (92) Image [A] is a posterior view of a lumbar spine model, right-side down. Image [B] is the force-plate.



In this experimental setup the adjustive forces applied to the spinal segment (A) produce reactive forces in a force-plate (B) that can be recorded and quantified to develop a 3-dimensional understanding of the adjustment. (Z = perpendicular force and reaction, Y = longitudinal, X = lateral). (92)

This writer would argue that a skilfully performed lumbar side-lying pull-move (or finger-push move should deliver an adjustive force reasonably well localised about the target segment, however poor technique may easily result in a less specific adjustment as appears to be reported by Beffa and Mathews. (79) Similarly, the SIJ is a joy to adjust because it can be very specifically targeted, in theory, but again, as the authors point out the technique can easily become a long-lever general mobilisation move as opposed to an adjustment.

It is not my intent to be critical of the adjustive technique utilised in such studies however designs of this nature almost guarantee a fifty/fifty (chance) outcome which is indeed what is reported. The more telling observation is one common to most studies on the phenomenon of cavitation, namely the subjects appeared to be asymptomatic. It appears that normal healthy students were randomly allocated to receive either the L5 pull-move or the side-lying SIJ adjustment. The core question thus becomes one of whether there was a clinical entity indicating a need for adjustment in the target segment or whether the adjustment was delivered to an asymptomatic target segment, an unethical act which should never have been approved by any research ethics committee.

The argument I make is one that supports the traditional concepts of Chiropractic, namely that a skilled clinician should demonstrate a reasonable degree of specificity with the adjustment. Bartlett Palmer repeatedly stated

> 'The Chiropractic objective is to locate the points in the spine where nerve pressure exists, due to subluxated vertebrae, and, thru proper adjustment by hand. to restore such subluxated vertebrae to their normal position … renewed health is the natural result'. (93)

Palmer expanded on this in his 1934 textbook (94) in favour of perceived specificity in so much as it is believed that an adjustment is a therapeutic act requiring a very high degree of psychomotor skill whereas mobilisation of one or many segments may be achieved almost by accident. The intervention must be delivered by skilled clinicians who can conceptualise and visualise adjusting a specific level as opposed to manipulating a spinal region.

Future research must adopt this approach where a panel of experts who would agree on the level, as with Holt's lovely work, (95) and perhaps prescribe the nature of the adjustment which would then be delivered by a trained, skilled and experienced Chiropractor. A different set of data may emerge once these variables are adequately controlled. I am a little loathe to be enthusiastic with the idea that a group of experts would advise the nature of the adjustment as I do think that decision should remain the prerogative of the Chiropractor who adjusts the segment, but I strongly believe the experts could determine the segmental level and allow the Chiropractor to adjust that segment at her or his discretion. Of course, it must be stated that the subject in such cases must be symptomatic as confirmed by the panel of experts.

There are so many ethical issues associated with delivering a powerful therapeutic intervention to a potentially asymptomatic SMU that it is clear that most studies into the question of cavitation and its relationship to the adjustment as a therapeutic intervention must now use symptomatic subjects. I appreciate this presents an extra complication in the design of such a research project but I can no longer accept that an intervention as powerful as the Chiropractic adjustment can continue to be delivered to an asymptomatic subject.

Should research teams apply this approach it may help with understanding why earlier studies into the nature and characteristics of cavitation sounds are ambivalent. The paper by Beffa and Mathews (79) includes a valuable summary of earlier work on this topic which will not be repeated here.

> A central argument in this paper is that the adjustment is a therapeutic intervention that should only be examined under therapeutic conditions, i.e. where the subject (patient) is symptomatic, the nature of the target lesion is identified and documented, and the clinician has acceptable experience in delivering the nominated intervention.

An analogy would be a study of the ability of a cardiac intern vs. a cardiac surgeon to excise and replace theoretically blocked cardiac arteries in asymptomatic patients without any diagnostic workup; this scenario would simply not happen. Likewise, applying an adjustment in the absence of a documented spinal lesion such as within a VSC must not happen.

In the research setting weak protocols allow findings such as those of Gal et al (96) that may be irrelevant in the clinical context. They reported that after several attempts, an adjustive thrust to the spine of an unembalmed cadaver produced a cavitation. Maigne and Vautravers (77) did likewise and even incised the cadaver's L4/L5 facet joint capsule to demonstrate post manipulative gapping of the joint surfaces. The clinical value of these findings remains questionable.

> It is argued that data with greater relevance may be established using a methodology which more closely approaches clinical reality. At this time I can only reinforce Chiropractic's empirical belief that the adjustment can be delivered in a relatively specific manner. The achievement of this outcome is highly dependent on the skill of the clinician and the thoroughness of their

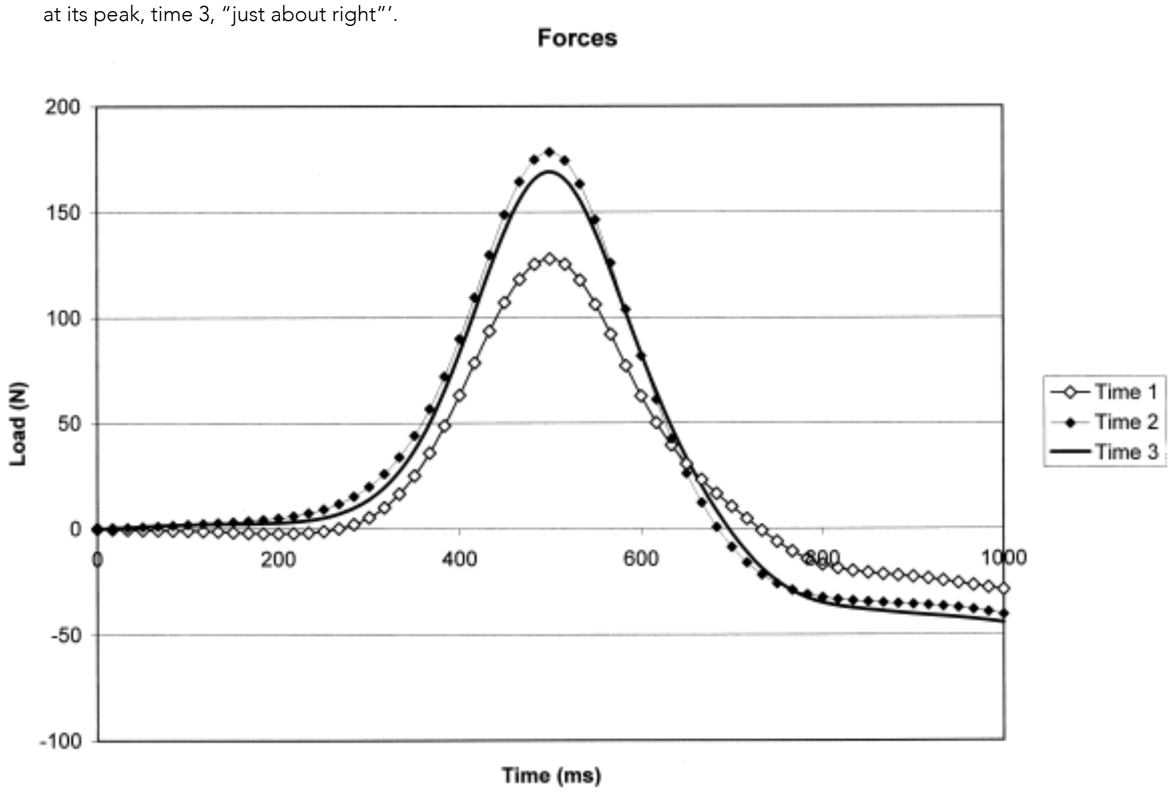
diagnosis and assessment. The process of visualisation is considered important for providing a context that can be documented for the subsequent clinical act of delivering the adjustment.

And when all is said and done, the patient outcomes tell the real story.

The biomechanics of the adjustment

The typical force-time curve for a lumbar adjustment is given in Figure 6. Taken from data published by Rogers and Triano (97) and expressing force as Newtons (N) against time in milliseconds (ms) it shows that a peak adjustive force of between 127.88 N and 178.27 N is delivered in less than 300 ms from thrust commencement. Figure 6 shows that performance improves with training.

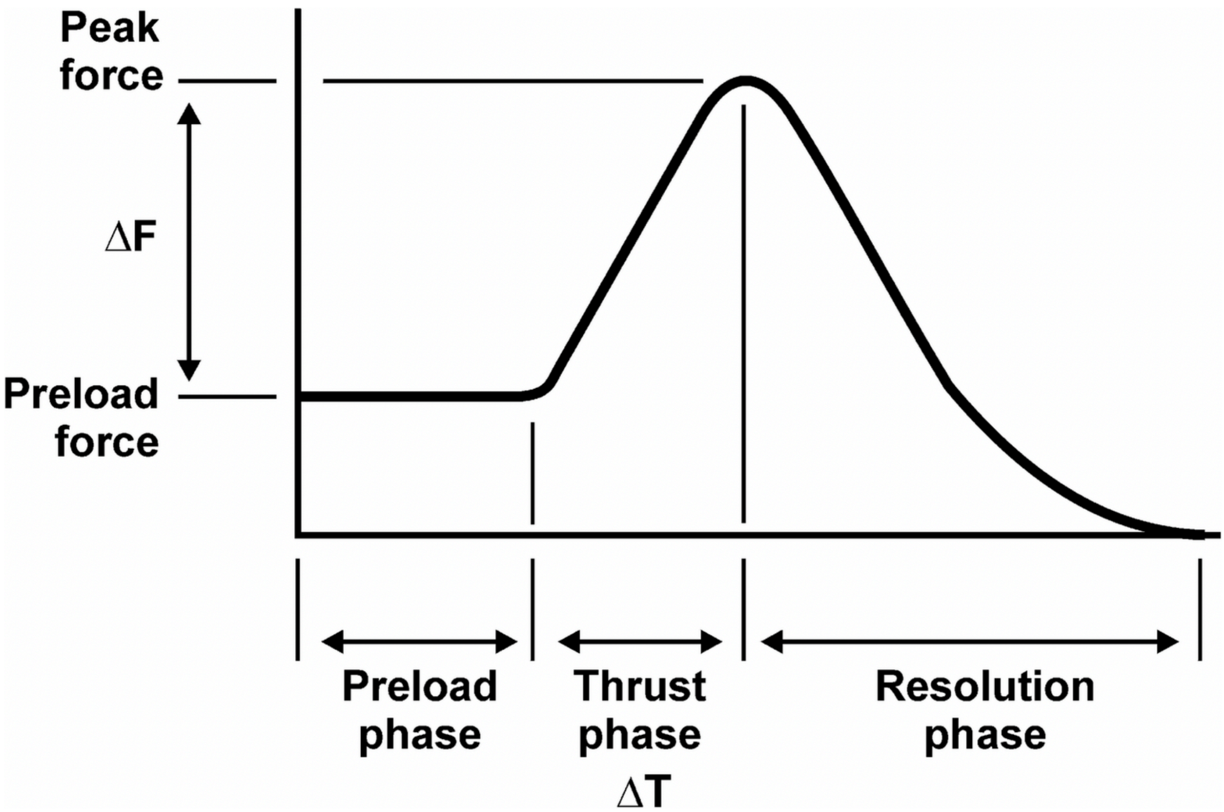
Figure 6: Showing the force magnitude over 1 second from base-line data (Time 1) and then after 5 weeks (Time 2) and then after a further 4 weeks (Time 3). The peak load was significantly different between times 1 and 2, reflecting a skills-gain due to training. (967) My view: 'time 1 weak and "scared", time 2 over-enthusiastic at its peak, time 3, "just about right"'.



The known shape of the force-time curve for an isolated adjustive thrust allows the generation of a broader curve to capture the forces involved from the setup to the resolution phase of the adjustment (Figure 7). This plot is now accepted as the standard 'force-time' chart and clearly identifies three phases of the adjustment:

- a preload phase typically of variable duration but consistently a steady application of a relatively low force,
- a treatment phase Δt that commences with the application of the adjustive thrust at the end of the preload phase and lasts to the point of peak force, and
- a resolution phase from the point of the peak force to a time where practitioner contact is broken from the patient, and typically approaching the force levels found during preload.

Figure 7: The now standard, stylised, force-time plot for a Chiropractic adjustment performed by a skilled clinician. (98)



Given the nature of the forces developed during all three phases of the spinal adjustment the question of whether there would be any difference between male and female clinicians was investigated by Forand et al. (99) They found that the three phases shown in Figure 7 are common to all Chiropractic clinicians regardless of gender and somatotype.

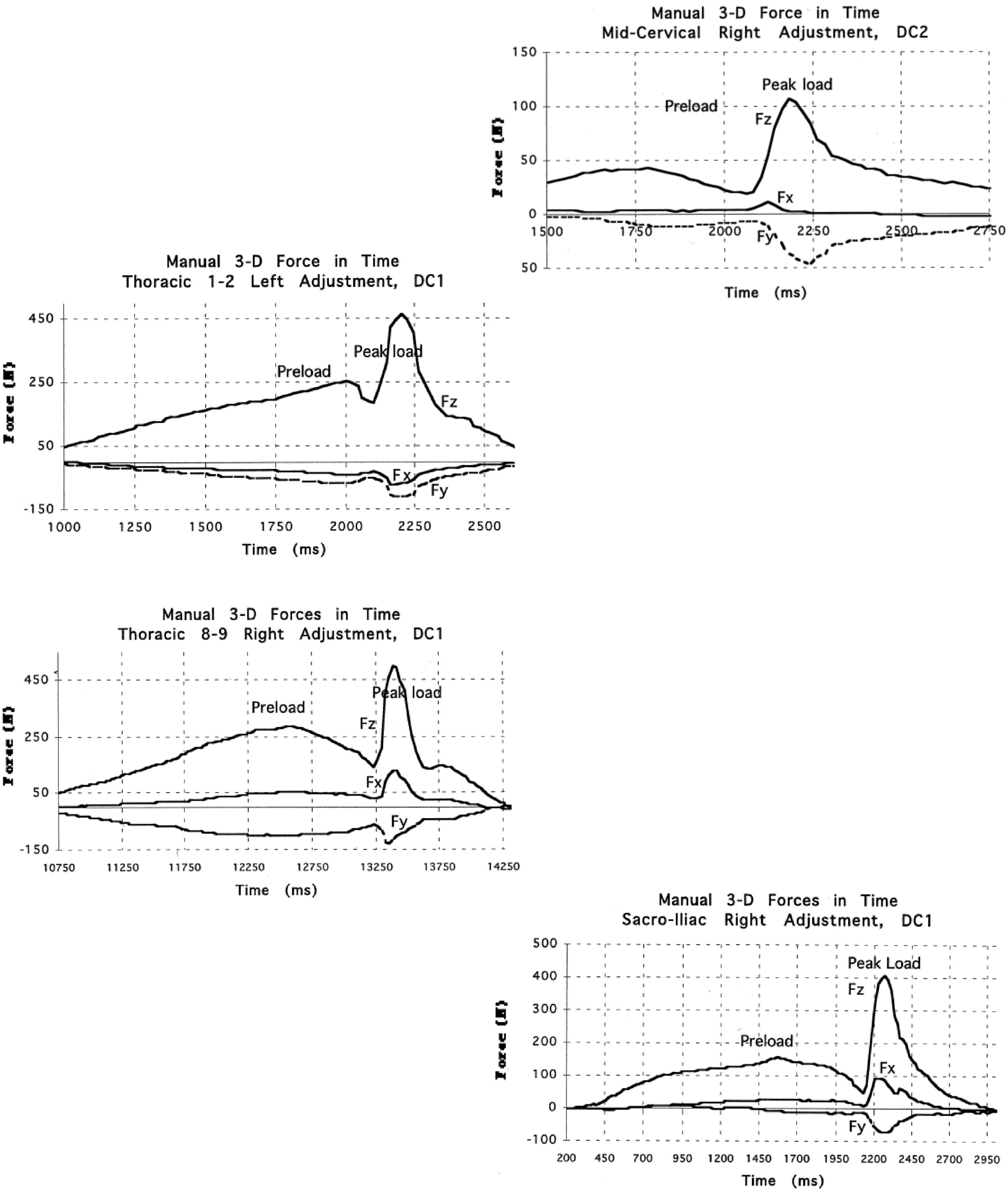
Their mean data demonstrate no significant difference between female and male Chiropractors delivering a posterior to anterior spinal adjustment in the vicinity of T4. The mean data clearly replicate the preload, treatment and resolution phases. The mean treatment time for (the period from preload to peak force) of 120 ms for males and 132 ms for females equates to the concept of 'high velocity' as it is commonly used to describe the Chiropractic adjustment.

Forand et al's data (99) show preload forces ranging around 137 to 138 N and a mean peak force during the treatment phase of 462 to 482 N. The resolution phase is the period from the time of peak force and in the data reported is a variable affected by standardising the data graphs. In the clinical situation the duration of the resolution phase will vary between being quite short, as with a recoil thrust, or quite long, as with a 'set and hold' thrust.

At this time it is not known whether the duration of the resolution phase has any meaningful clinical application and its description is probably more reflective of a particular philosophical stance than of clinical merit. For example, the descriptor 'set and hold' presumes a bone is being moved back to a certain position and requires being held in that position until the soft tissues around it settle and adapt to the new position. This concept has little if any grounding when the adjustment is considered as being more neurological than biomechanical. With the demise of the 'bone out of place' theories, such descriptors seem to be more of historical interest than of clinical relevance. On the other hand a recoil thrust probably achieves its clinical effect through the sheer speed of the thrust delivery which is enhanced by the recoil technique rather than by the rapid if not instantaneous removal of the clinician's hands following the attainment of the peak adjustive force.

The above data are uni-planar, being reported for measurements in one degree of freedom. The following data reported by van Zoest and Gosselin (100) incorporate readings for each of the 3 axes and allow a 3-Dimensional representation of the forces created by the chiropractic adjustment.

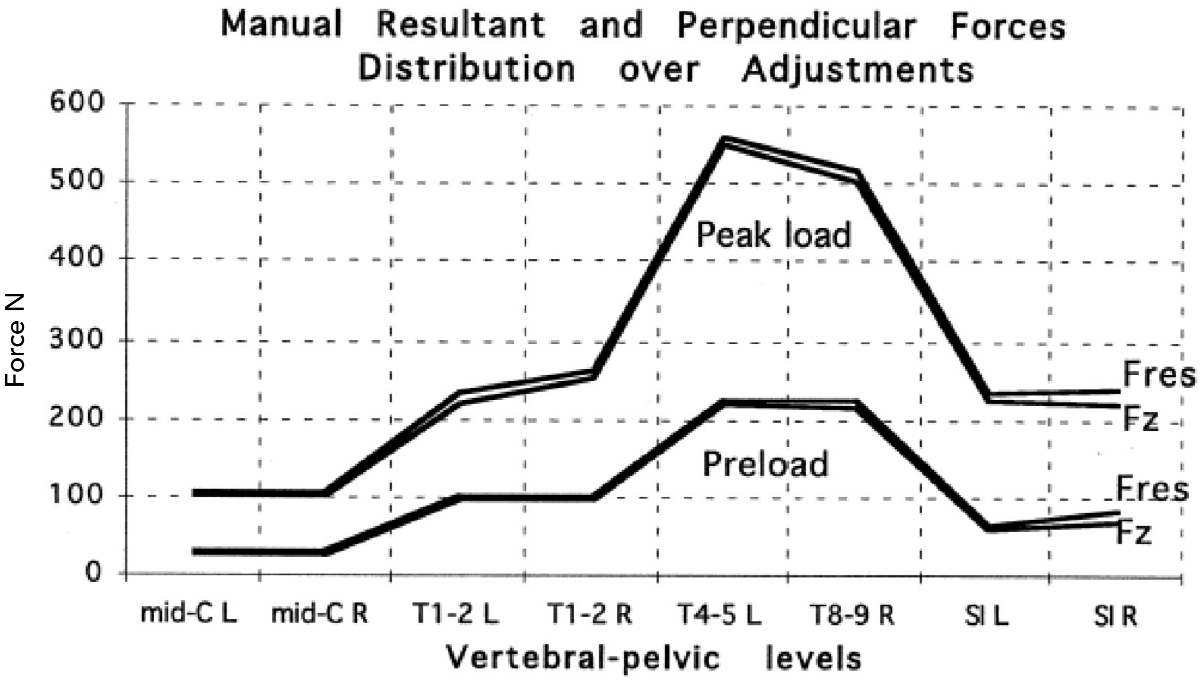
Figure 8: Depending on the spinal level, the adjustment delivers peak load forces which differ by spinal level within about 90 ms (Cx), up to 150 ms (Tx) and between 166 and 182 ms (SIJ). (100)



The data are shown in Figure 8 are for spinal levels at the mid cervical, upper, mid and low thoracic, and the sacroiliac joint. The plots from van Zoest and Gosselin's data demonstrate the nature of the combined vectors. The plot for the Z axis (Posterior to Anterior thrust) most closely resembles the typical plots established by Triano and by Forand.

The graph shown in Figure 9 plots the forces for the preload and the peak adjustive load by spinal level. This shows the interesting finding that the adjustment delivers peak load forces of around 102 to 104 N in the cervical spine, 506 to 554 N in the mid and low thoracic spine, and 220 to 228 N at the sacroiliac joint. The elapsed time for the delivery of these significant forces is reported as within about 90 ms in the cervical spine, up to 150 ms in the thoracic spine and between 166 and 182 ms for the sacroiliac joint.

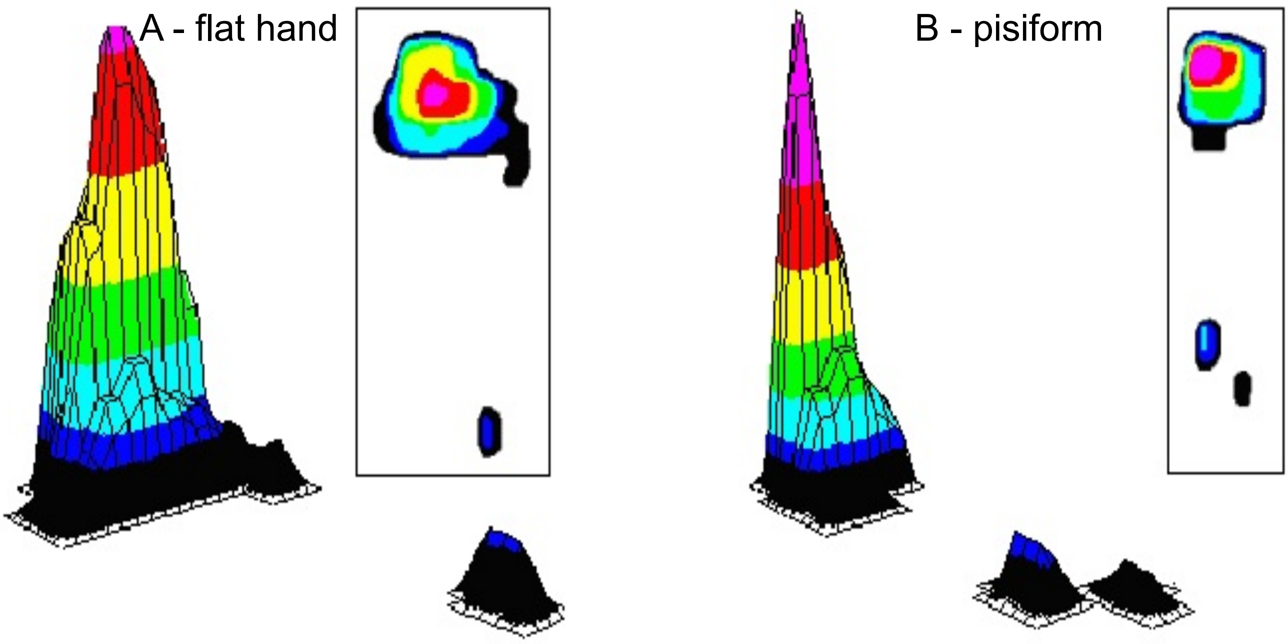
Figure 9: Depending on the spinal level, the adjustment delivers peak load forces of around 102 to 104 N (cervical spine), 506 to 554 N (mid and low thoracic spine) and 220 to 228 N (sacroiliac joint) within about 90 ms (cervical spine), up to 150 ms (thoracic spine) and between 166 and 182 ms (sacroiliac joint). The plot of the preload forces matches that of the peak load. (Fres = 3-Dimensional resultant, Fz = the matching 1-Dimensional perpendicular Z force). (100)



When it comes to the argument of whether the intervention is an adjustment or a mobilisation, the data shown in Figures 10 A, B are relevant. (101) They report that the traditional 'arched' hand used for the Chiropractic adjustment that positions the contact point as the pisiform produces a much more localised adjustive input to the target segment (Figure 10A) than a poor hand configuration that ends up splaying the adjustive force over a broader area (Figure 10B). Something as simple as ensuring the correct hand posture may well make a significant difference in localising the adjusting force to a specific level, a variable researchers must control when planning future studies.

Van Zoest and Grosselin (100) found that the 3-Dimensional components of applied force for the adjustment were significantly different between the spinal levels, suggesting an awareness of different dynamics for the adjustive techniques at each level. Empirically this information is a given and it is to be expected that the values of the preload and adjustive load will vary considerably between the levels; this is associated with a variable ratio between the peak adjustive load and the mean preload at each spinal level. These are the first investigative data that demonstrate the variability in the nature of the adjustment to reflect the variable anatomy and biomechanical dimensions of each spinal level in general and at the SIJ in particular.

Figures 10 A, B: Showing a 2-Dimensional (boxed) and 3-Dimensional isobar representations of pressures recorded from a single subject during the setup for an adjustment using the pisiform. Figure A represents the pisiform (top) and light finger contact (lower) and is more precise or specific in its segmental contact. Figure B shows the less concise contact of a flat hand as used in manipulation. Configuration A allows specificity, configuration B does not. In fact, 'B' is representative more of a calcaneal or palmer contact, with no specificity. (101)



Another beautiful finding within these data is the consistent replication of the pattern identified earlier, namely preload, treatment (HVLA adjustment) and resolution. These outcomes are consistent for a mid cervical adjustment delivered with the patient supine, three thoracic moves delivered with the patient prone, and a sacroiliac adjustment delivered with the patient in the side-lying position.

It can therefore be safely stated that regardless of the spinal level and regardless of the style of adjustment, it will be delivered with a preload phase, an adjustive or treatment phase, and a resolution phase.

There are two further interesting findings in these data: first, each of the plots for the load on the Z-axis at each of the spinal levels and the SIJ shows a lessening of the preload immediately before the rapid application of the adjustive load. This probably represents the clinician taking the joint to tension and thus achieving a greater load during preload and then easing back to judge the tissue-sense of the setup and thus lighten preload immediately before the rapid application of the adjustive force. It should not be interpreted as a deliberate 'lift-off' of the contact as may be seen in poor setups where the clinician 'bounces' back from preload and then into the adjustive action.

Second is the negative load evident in the Y-axis concurrently with the peak adjustive load in the Z-axis. This tends to suggest there is a component of force along the Y-axis within the adjustment. Whether this is long axis distraction or compression or a variable combination of both reflecting the inquisitive nature of the setup during preload and then the thrust itself is yet to be determined.

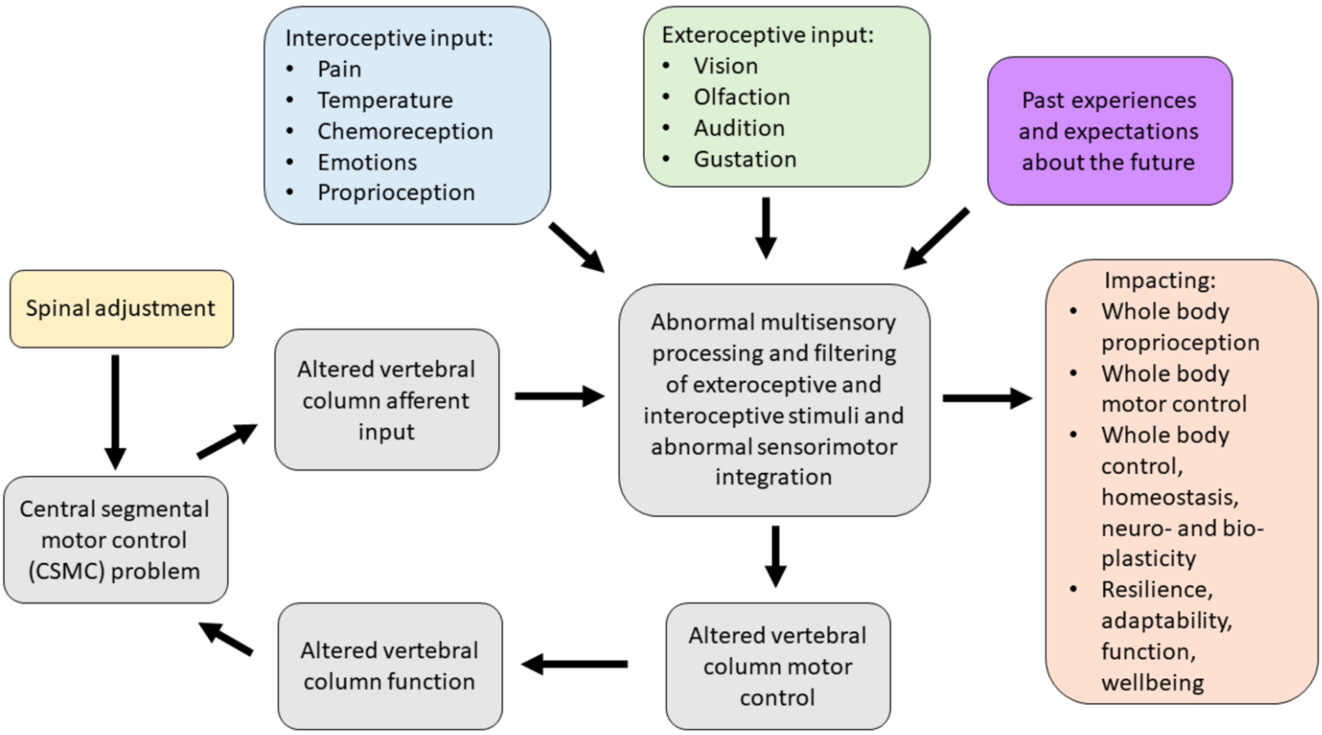
Van Zoest and Gosselin (100) are the first to report the 3-Dimensional nature of the adjustment and to describe their technique of data collection, first reported in 2003. The use of their instrument has the potential to provide a more complete and differentiated characterisation of the patient and practitioner forces associated with spinal, and other joint, adjustment.

Haavik's understanding of the adjustment

With reference to Figure 11, I cite verbatim from Haavik's invited review 'The contemporary model of vertebral column joint dysfunction and impact of high-velocity, low-amplitude controlled vertebral thrusts on neuromuscular function': (102)

> Haavik et al present a 'contemporary model of the mechanism by which central segmental motor control (CSMC) problems and spinal adjustments result in neuroplastic consequences that impact neuromuscular function. The grey boxes, depicting the impact of proprioceptive input from the deep paraspinal muscles on spinal motor control, suggest that vertebral motion segments that have CSMC problems cause altered proprioceptive input, which alters multi-sensory processing, filtering and integration, along with both interoceptive and exteroceptive stimuli, resulting in abnormal sensorimotor integration of this spinal input. This impacts vertebral column motor control that could alter vertebral column movement/function, causing micro-traumas to induce ongoing spinal dysfunction. These grey boxes are therefore seen as a self-perpetuating cycle of abnormal spinal column motor control, that over time, may lead to the development of recurrent and chronic spinal pain. When the spinal HVLA adjustment (yellow box) is applied to a CSMC problem, this may improve proprioceptive input, which in turn improves multi-sensory interoceptive and exteroceptive integration, thus improving motor control of the vertebral column. The orange box to the right highlights that CSMC problems and adjustments do not just impact the motor control of the spine (i.e. the grey boxes), but also appear to influence motor control of the rest of the body, as well as potentially impacting whole-body awareness, integration, adaptability, function, and wellbeing. The validity of this contemporary model and the degree to which it is supported by the literature is discussed'. (102)

Figure 11: Haavik et al's contemporary model of the effects of the Chiropractic adjustment



Conclusion

There is much more to be said about the adjustment including matters such as the selection of technique and the potential for adverse events. These are explicit matters for a 'how to' technique book describing the range of usual Chiropractic techniques and must be studied and learned under the close supervision of a qualified and registered Chiropractor.

All Chiropractors are encouraged to undertake specialist training once the basic generalist skills have been mastered prior to entering the profession. Most will chose a skills paradigm with which they relate, for example Activator Methods, Gonstead Methods, Atlas Orthogonal (AO), and so on. Many will also include learnings from the field of Applied Kinesiology. Personally I can't see any one established paradigm of Chiropractic being superior to any other, but I may be so bold as to suggest that

> The ideal Chiropractor will be a master practitioner in one technique paradigm with capability in one or two other technique paradigms to be able to best select the type and style of intervention best suited to any particular patient, and will inform their analysis of the spine with methods beyond any one technique paradigm, preferably Chiropractic-centric investigative approaches as seen in AK and/or SOT and perhaps supported with devices such as posture scan and scanning EMG, or even the humble Nervoscope. Radiographs will remain essential informants.

While some Chiropractors may claim to use diversified technique it must be noted that there is no such specific set of clinical skills called 'Diversified Technique'. Rather it is an ad hoc collection of manipulative techniques and some adjusting techniques and is a rather low-level representation of the true Chiropractic skills-set.

An underlying principle is recognition of both neurophysiological mechanisms as well as the mechanisms of action of the chosen technique that may apply in specific cases. I personally feel the techniques collected as 'diversified' lean more towards the mechanical dimension of the subluxation, while ample evidence shows that segment-specific techniques such as AO and Gonstead achieve significant neurophysiological changes.

There is a spectrum of manipulative skills (Figure 1) that start at a basic level with manual treatment such as massage and specific muscle and soft tissue techniques and progress through a range of techniques collectively considered as mobilisation, a passive movement by the clinician of a joint or number of joints in the patient, usually by means of long levers, that may or may not include an impulse, and peak with the segment-specific Chiropractic adjustment as technically described here.

The adjustment is the highest order manual therapeutic skill for the reasons shown in Figure 11. In essence, the adjustment with cavitation at the prescribed speed and depth initiates a neurophysiological cascade impacting the whole person.

The evidence presented in this paper demonstrates that the spinal adjustment is characterised by the extremely skilled high-velocity, low-amplitude thrust into a level or levels of the spine, pelvis or other articulation that is perceived by the clinician to demonstrate a range of indicators for such intervention. Depending on the spinal level, the adjustment delivers forces of around 102 to 104 N (cervical spine), 506 to 554 N (mid and low thoracic spine) and 220 to 228 N (sacroiliac joint) within about 90 ms (cervical spine), up to 150 ms (thoracic spine) and between 166 and 182 ms (sacroiliac joint). These variables do not differ significantly between male and female chiropractors and are refined with training and practice.

Skilled spinal adjustment is a conservative intervention and is only indicated following a specialised examination and diagnosis of the patient, and may be supported by other manual treatments, exercise and patient education. When performed by fully-trained and experienced Chiropractors the adjustment is an extremely safe clinical intervention yet as with all therapeutic interventions there are risks, cautions and contraindications. These must be explored in an appropriate and thorough clinical history and examination of the patient prior to including adjustment within the patient's management plan.

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