Activator Methods Chiropractic Technique

Purpose: A review of the Activator Methods chiropractic technique (AMCT) and Activator adjusting instrument (AAI) is presented. History and development of the technique and its evidence basis and safety issues are discussed. **Method:** Activator history and associated body of research literature on both the technique and the instrument are critically reviewed. Included are basic science research in biomechanics, neurophysiology, and clinical research in AMCT analysis reliability, case studies, prospective cohorts, randomized group clinical outcomes, and comparisons to hands-only treatments. **Summary:** AMCT and the AAI represent a system and mode of delivery based on rational and empirical evidence that continues to be informed by an active and growing body of clinical research. In comparison to other techniques, AMCT appears equivalent to various hands-on approaches, but with less physical demand on the doctor of chiropractic. As with all spinal manipulative and other therapies, risks of adverse effects exist, but appear to be minimized due to force and velocity characteristics of the AAI. Needs for future research directions are also discussed. **Key words:** *chiropractic, clinical protocol, leg length inequality, research*

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ACTIVATOR METHODS Chiropractic Technique (AMCT) is based on a dynamic approach to spinal and somatic dysfunction in which biomechanical lesions are isolated and identified through patient movements designed to isolate and reveal the exact areas of dysfunction. With detection, treatment is provided through a mechanical instrument designed to deliver a preset amount of force precisely to correct the lesion. The primary indicator of lesion and response to treatment is the difference in leg lengths of the prone patient.

AMCT is taught in the majority of U.S. chiropractic colleges and is offered at international chiropractic colleges. Approximately 45,000 doctors of chiropractic throughout the world now use this technique. Recent surveys by the National Board of Chiropractic Examiners show that AMCT is one of the two most widely used chiropractic techniques in the United States.[1] In the United States, the percentage of practitioners using AMCT increased from 51.2% in 1991 to 62.8% in 1998. Chiropractors reported using AMCT with 21.7% of their patients in 1998. In Europe, it was estimated the technique was used in 14% of chiropractic cases in 1994.[2] The AMCT is also widely used in Canada[3,4] and Australia.

Activator cofounder and president, Arlan W. Fuhr, DC, initiated scholarly research for the purposes of improving and demonstrating AMCT's value to chiropractic, the broader health care system and the general public. Research and development of AMCT has yielded returns in the knowledge of anatomy, biomechanics, and neurophysiology. Many of

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these studies addressed fundamental questions not fully understood and articulated by the chiropractic profession, including spinal biomechanics and energy and resonance characteristics of the chiropractic adjustment.

HISTORY OF ACTIVATOR METHODS

Instrument adjusting in chiropractic dates to the early years of the profession. According to Keating, instrument adjusting "was apparently an ancient and indigenous American art."[5] He cites a report by Dorn,[6] a chiropractor who bought an instrument that may have been used by Montana Crow Indian medicine men to relieve digestive ailments. The Crow used a type of thrust perhaps similar to a percussion treatment. As early as 1901 Minnesota chiropractors were using the "stick method" developed by Thomas H. Storey, DC, a 1901 graduate of D.D. Palmer.[7] Storey employed a wooden mallet and a stick covered with what appeared to be a rubber tip from a crutch to "set the spine."[8] D.D. Palmer himself, sometime after 1910, had a "rubber hammer (pleximeter) with which he experimented adjusting vertebrae."[9]

During the 1960s, Drs. Warren C. Lee and Arlan W. Fuhr practiced Logan basic and Toftness low-force adjustment techniques. Lee and Fuhr sought to establish better, more sensitive clinical assessment methods for identifying subtle musculoskeletal dysfunction and segmental facilitation and to assess when improvement in the patient's condition had occurred. They experimented with procedures to assess preadjustment status and postadjustment clinical outcomes. In 1965, Fuhr learned the directional nonforce technique. These procedures involved preadjustment and postadjustment leg length measurements and double thumb-lock toggle adjusting. Fuhr later met Mabel Derifield, DC, and integrated the Derifield system of pelvic analysis using a relative leg length measurement.

In 1985, Activator Methods was awarded a small business innovative research National Institutes of Health (NIH) Grant for the study of safety and effectiveness of the mechanical adjusting instrument on osseous structures. In 1990, the AMCT published the critical self-review entitled "The Current Status of Activator Methods Chiropractic Technique, theory, and training."[10] The first peer-reviewed paper concerning AMCT history appeared in the *Chiropractic Journal of Australia* in 1994,[11] and a more complete history subsequently appeared in the 1997 AMCT textbook. Cooperstein[12] noted AMCT to be the first and perhaps only technique system to apply the Kaminski model for chiropractic technique validation.[13]

DEVELOPMENT OF AMCT ISOLATION TESTS

Dr. Fuhr discovered isolation tests circa 1976, when he noted leg length changes in response to positional changes of body structures affected by somatic dysfunction. Fuhr observed and codified observations of musculoskeletal imbalances in the lumbar, cervical, and the extraspinal regions of the body. This became the system of analysis known today as AMCT isolation testing.

Prone leg length comparisons in response to isolation testing became the AMCT indicator for determining sites and occasions to adjust. The functional short leg was named the *pelvic deficient* side by Fuhr. The functional short leg is not anatomically short, but rather appears shorter because of presumed obliquity in the pelvis. This phenomenon led to the development of a series of provocative maneuvers to test for joint mechanical dysfunctions of the vertebrae and other articulations. As the technique was taught to other chiropractors, these chiropractors in turn began sending in their own clinical observations. These were tested by Lee and Fuhr and eventually submitted to a standard of care review panel of AMCT instructors. Tests considered clinically useful were incorporated into the main body of AMCT technique protocol.

RELIABILITY OF LEG LENGTH ANALYSIS

Reliability studies on prone leg length inequality (Activator Methods Position 1) established it as a potentially stable clinical phenomenon, with a good degree of agreement among trained examiners.[14–17] Jansen and Cooperstein[18] found that the functional short leg is a reproducible clinical entity when they used a chiropractic table with friction-free plates. They observed leg length changes under a variety of postures and movements in prone subjects.

Four examiners who evaluated 30 subjects by means of the AMCT leg length procedure in Position 1, found that five of six pair-wise interexaminer comparisons yielded "good" concordance ($\kappa = 0.53$).[14] Order of examiners was not randomized, creating the possibility of unwanted order effects. Their results were confirmed in a later study by Nguyen HT and colleagues, in which 34 subjects were examined by two experienced AMCT instructors, yielding a total agreement of 85% ($\kappa = 0.66$, $p < 0.001$).[17] In this study the order of examiners was randomized to control for order and practice effects.

Youngquist, Fuhr, and Osterbauer[16] reported the first study to evaluate the interexaminer reliability of isolation testing. They sought to determine whether prone leg length analysis in association with an isolation test maneuver was reproducible. Two examiners evaluated 72 subjects who were divided into groups of 34 and 38 patients on two separate occasions. Subjects were evaluated for the presence or absence of atlas segment (C1) subluxation by observing leg length inequality. Agreement was well beyond chance for the two samples, with $\kappa = 0.52$ ($p < 0.01$, n = 24) for the first sample and $\kappa = 0.55$ ($p < 0.001$, n = 48) for the second.

De Witt and colleagues[15] investigated leg length inequality following isolation maneuvers. They employed sophisticated optoelectric measuring equipment. Eight healthy subjects were compared to eight subjects with a history of chronic spinal complaints. As a result of prone neck extension ("head up") maneuvers (the C5 isolation test), patients exhibited significantly more asymmetrical (right versus left) heel movement than controls.

The reliability of leg length checks is distinct from validity of leg length observations. The former refers to the consistency of findings (over time or between examiners), the latter to the clinical meaningfulness of observed leg length inequality. Although studies of the reliability of these procedures have provided support for consistent findings among examiners (in Position 1), the validity of AMCT leg length analysis (and associated isolation, stress and pressure tests) has not been directly studied to date.

However, several investigations provide indirect data bearing on the meaningfulness of AMCT leg length evaluations. As mentioned previously, DeWitt[15] showed isolation maneuvers (cervical extension) produced measurable leg length changes. Shambaugh and colleagues[19] demonstrated that right and left cervical rotation produced leg length alterations.

AMCT BASIC SCAN PROTOCOL

The AMCT basic scan protocol is based on the premise that addressing the most common sites of involvement will resolve most minor dysfunctions or subluxations and of vertebrae not directly included in the basic scan. Judicious use of the basic scan protocol is consistent with a sound tradition in chiropractic clinical practice (i.e., avoidance of overadjusting). One way to limit excessive adjusting is to adjust only major subluxations occurring at the major stress and transition points in the spine, typically the transitional vertebra areas. Subluxations of other vertebrae may occur secondarily or as compensations to these primary stresses in the dynamic structure of the spine by fixation or aberrant motion. Adjustment of major segmental dysfunctions may also eliminate compensatory or minor subluxations.[20] Tables 1 and 2 outline the principal assessments of the AMCT basic scan protocol. Position 1 refers to the patient prone with knees extended. Position 2 is the patient prone with knees passively flexed by the chiropractor.

The vertebral motor units and other articulations included in the AMCT basic scan protocol are listed in Table 3. Note that there are only a few "key" vertebrae listed for each region of the spine.

DEVELOPING THE ACTIVATOR ADJUSTING INSTRUMENT

The Activator adjusting instrument (AAI) was developed to mechanically replace the need for thumb toggling, a technique that produced extreme fatigue, muscle strain, and frequent elbow injury on chiropractors who practiced it. The ideal mechanism needed to produce a thrust, reduce physical stress on the clinician, and precisely control the speed, force, and direction of the adjustive thrusts.[21]

In 1966, Lee and Fuhr initially tried a dental impactor, designed to tap amalgam into teeth. However, this instrument failed as a spinal adjusting device because the impactor did not have enough speed or force. Several other devices were tested including a center punch (which required too much preload pressure) and an instrument with a moving stylus that caused too much patient discomfort. In 1967, Fuhr tried a surgical impact mallet designed to split impacted wisdom teeth. The scalpel was replaced with a brake shoe rivet, and a small rubber doorstop was attached to the end. This device used a hammer striking an anvil to produce a sudden shock force much like a croquet mallet striking two croquet balls. This apparatus tested successfully on patients and was the first functional ancestor of the modern AAI. This instrument was modified and used until 1976.

A later version that held up to the demands of daily practice was eventually designed by Dr. Freddy Hunziker. The Activator I was designed and built a more reliable internal mechanism for the instrument, which used a hammer-anvil effect to produce a safe, reliable, and controlled force to adjust osseous spinal structures.[11] The adjusting instrument was subsequently named the Activator and the analysis became known as the Activator Methods Chiropractic Technique.

RESEARCH AND DEVELOPMENT OF THE AAI

AMCT is one of the more extensively studied technique systems in chiropractic. The AAI, listed under the category of "mechanical force, manually assisted procedure," yielded a "promising to established" rating at the 1992 Mercy Center clinical guidelines consensus conference.[22] A consensus panel commissioned by the Canadian Chiropractic Association granted a similar rating for the AAI.[23]

Biomechanical research

Greater understanding of biomechanics and neurophysiological research has led to refinements in the AAI. In the 1980s and 1990s, research on spinal manipulation shed light

Table 1. Summary table of tests and adjustments AMCT Basic Scan Protocol*

Possibility 1:	Raise legs to position 2; PD leg lengthens	
Subluxation	**Test performed**	**Adjustment: Contact + LOD**
Knee		
Medial knee joint	Pressure test medial collateral ligament lateral and inferior	Contact medial knee joint—LOD is lateral and inferior
Talus	Adjust when test for medial knee joint is positive	Contact medial border—LOD is posterior-superior and lateral
Lateral knee joint	Pressure test lateral collateral ligament medial and inferior	Contact lateral knee joint—LOD is medial-inferior
Cuboid	Adjust when test for lateral knee joint is positive	Contact inferior lateral aspect—LOD is posterior-superior and medial
Pelvis		
AS ilium	Pressure test crest of ilium inferior-medial	Step 1: Contact base of sacrum on side opposite PD—LOD is anterior-inferior Step 2: Contact crest of ilium—LOD is inferior-medial Step 3: Contact ischial tuberosity—LOD is anterior-inferior
PI ilium	Pressure test under sacrotuberous ligament posterior-superior and lateral	Step 1: Contact spine of ischium—LOD is posterior-lateral and superior Step 2: Contact sacrotuberous ligament—LOD is posterior-lateral and superior Step 3: Contact lateral aspect of ilium—LOD is anterior-superior
Symphysis pubis	Instruct patient to squeeze knees together	
Superior pubic bone	When PD leg lengthens going to position 2	Contact superior aspect of pubic bone—LOD is inferior
Inferior pubic bone	When PD shortens going to position 2	Contact inferior aspect of pubic bone—LOD is superior

AMCT indicates Activator Methods chiropractic technique; PD, pelvic deficient side (short leg); LOD, line of drive; AS, anterosuperior (ilium); PI, posteroinferior (ilium).

*The AMCT basic scan protocol will be continued by next testing L5 and the rest of the vertebrae and shoulders as indicated.

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on the nature of the chiropractic adjustment in terms of time, force, duration and physiological effects—as delivered by hands only and by the AAI. There have been two general categories of investigation: biomechanical and neurophysiological. The AAI evolved in response to current knowledge in both domains. Under the biomechanical model, issues such as tissue compliance (stiffness), response to input force (impedance), and natural frequency resonance of the spine were

Table 2. Possibility 2: Leg stays short or becomes shorter upon flexion*

Raise legs to position 2—PD leg shortens		
Subluxation	**Test**	**Adjustment**
L4—subluxated on side opposite PD	PD leg goes short on raising legs to position 2	Contact mammillary process on L4 on side opposite PD—LOD is anterior-superior

AMCT indicates Activator Methods chiropractic technique; PD, pelvic deficiency.

*Continue the rest of the AMCT basic scan protocol by next testing L2 and the rest of the vertebrae and shoulders as indicated.

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Table 3. Activator Methods basic scan protocol

Lower extremities
Medial knee
Lateral knee
Upper thoracic spine
T6 and corresponding rib
T4 and corresponding rib
T l and first rib
Upper extremities
Medial scapula
Lateral scapula
Pelvis
AS ilium
PI ilium
Symphysis pubis
Cervical spine and occiput
C7, C5, C2, C1
Lumbar spine
L5, L4, L2
Thoracic
T12
T8 and rib as indicated

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explored. In neurophysiological investigations, threshold frequencies and minimal forces required for stimulation of joint mechanoreceptors were investigated.

Two biomechanical publications emerged from the initial 1985 NIH grant. This led to Fuhr's first papers in the *Journal of Manipulative and Physiological Therapeutics*.[24,25] The first study introduced a novel impedance-head–equipped spring-loaded AAI that caused measurable bone movement and detectable electromyographic (EMG) response. This article encouraged investigation of relative bone movement in response to light manipulative taps to the spine. One millimeter relative translations and 0.5 degrees of rotation occurred during the first 19 milliseconds. This was the first study to confirm that an AAI thrust could induce motion in a bone, although the first research subject was a 40-pound dog. In the second article, the authors suggested that with further development piezoelectric accelerometers attached to an Activator could be a noninvasive tool to study dynamic, relative bone movement.

The next research objective was to investigate the effects of AAI adjustments on the human spine in vivo. This procedure required insertion of "Steinman pins" into the spinous processes of human subjects under local anesthesia. The pins were placed into the spinous processes of the L4 and L5 vertebrae of a live subject and Activator thrusts were made on the spinous processes from T11 inferior to the L2 level. These thrusts exerted peak forces of approximately 72 newtons. In response, the L4 and L5 vertebrae experienced an axial displacement, posteroanterior shear displacement, and rotational displacement at the L3-L4 spinal segment levels.[26,27] Coupled spinal motion was clearly detected in more than just the vertebra receiving a direct thrust. This study provided the first substantiated evidence in humans of vertebral displacement produced by an adjusting instrument.

Subsequent biomechanical research conducted with Keller and others found, among other things, that when the instrument was equipped with a particular type of impedance head, it produced "a significant improvement in the frequency content" of the force delivered to the spine.[27–31]

Subsequent research guided further improvements in the force-frequency spectrum of the AAI. That is, as force delivery from the instrument was compared to known and discovered characteristics of the spine and nervous system, the instrument itself was refined to match these characteristics. As an example, the Activator II adjusting instrument incorporated an additional integral mass (about 45 g) attached to the stylus, which reduced momentum and thus better matched the resonance frequencies of the spine.

Later, it was found that by adding a preload control frame, impedance measurements were more reproducible. This meant preload compression that would reduce force and change frequency of the AAI springs were eliminated.[26,30] These results demonstrated an enhancement of the force-frequency spectrum, leading to development of the Activator III. Figure 1 is a summary of the different characteristics and improvements in the three Activator models. Comparing the force graphs shows improvement in performance in the AAI over its development. The force profile of the Activator II was enhanced over the frequencies of 10 to 100 Hz in comparison to the Activator I. The enhancement was increased by nearly two orders of magnitude (1.0 E4 for Activator II versus 6.5 E2 for Activator I). Activator III in turn enhanced the frequencies of 2 Hz to 100 Hz by yet another order of magnitude (1.0 E5 for Activator III versus 1.0 E4 for Activator II).

Certain biomechanical models suggest the spine responds—or resonates—most efficiently to specific frequency components of mechanical signals.[27] One finding in Activator research was that the spine has a natural posterior to anterior resonance frequency of between 30 and 50 Hz (cycles per second). This means that forces applied at this frequency are actually transmitted and magnified along the entire spine.[27,29]

Slower rate spinal manipulative therapy (SMT) forces (1 to 3 seconds) have not been found to produce neuromuscular reflex responses in the back musculature, regardless of whether joint cavitations were elicited.[32–36] This is consistent with the AAI in its design to impart a consistent high loading rate, short duration, multifrequency thrust that may not ordinarily be associated with an audible joint cavitation.

In investigating the effect of the AAI on live subjects,[27] the posterior mechanical behavior of the human thoracolumbar spine was found to be sensitive to mechanical frequency and showed significant region-specific and gender differences. In the frequency range of 30 to 50 Hz, the lumbar spine of this subject population was the least stiff and therefore had the greatest mobility. The results of this study indicated that dynamic spinal manipulative therapy procedures that induce impulses at this frequency would produce more spinal motion for a given force; given the muscle activity is kept to a minimum during thrust. Muscle action has the effect of dampening force input by absorbing it. This can alter the frequencies of the force reaching mechanoreceptors.[37] In this regard, spinal manipulative therapy procedures designed to target the resonant frequency of the spine require less force application. It appears that the frequency content of the AAI energy impulse associated with mechanical stimulation during SMT has a direct bearing on the subsequent physiologic response of the body (see Figure 1 for a comparison of the force frequency profiles of the AAIs).

Subsequently, the Activator instrument was used in a study measuring the stiffness of low back muscles in patients with and without chronic low back pain.[38] Activator manipulative thrusts were delivered to several lumbosacral spinal landmarks and neuromuscular reflex responses were measured. Findings established significantly greater stiffness in low back musculature on those with chronic low back pain. The prototype of the Activator III used in this study confirmed earlier design improvements.

Several studies suggest patients suffering from back pain respond as effectively to the AAI as they do to hands-only therapy using higher force, low-loading rate thrusts.[39,40] Instrument adjusting produces vibrations or oscillations in the spinal structures, whereas the latter is relatively localized or static in its effects, much the same as hands-only adjusting, which results in a joint cavitation and audible "pop" produced within the posterior spinal structures. The necessity for joint cavitation to produce therapeutic effects has been explored,[29,36] and is still is a source of controversy within the chiropractic profession.

Some evidence suggested that specific frequency components of mechanical signals[27,41,42] might influence or enhance the healing and remodeling of the musculoskeletal system (remodeling refers to the ability of biologic soft and hard tissues to alter their composition and structure in response to mechanical and systemic stimulation). Under this model, dynamic mechanical stimuli that match natural resonance characteristics of body tissues have a greater potential for therapy than discrete static mechanical thrusts without resonant frequency content. Hence the rationale for low-force dynamic chiropractic manipulations to affect the spine and paraspinal tissues. Hands-only manipulation to reduce joint fixation or produce changes in relative bone position may thus be effective by matching a frequency profile required for therapeutic changes. Thus "both magnitude and frequency of hands-only and mechanical thrusting manipulations are critical elements in determining therapeutic effects."[26,27,43]

Solinger further addressed the issue of resonance by comparing the spine to a damped harmonic oscillator model. He noted that hands-only and Activator spinal adjustments created the same oscillating frequencies of the spine, though the hands-only adjustments produced higher amplitudes.[29,43] Thus it may be inferred that both instrument and hands-only adjustments are similar in efficacy if oscillating frequencies are the important end result. Thus one might surmise that both treatments are equally the same in clinical application. This has been supported in some studies.[40,44]

Neurophysiological dynamics

Chiropractic adjustments delivered by AAI may "normalize" articular afferent input to the central nervous system with subsequent recovery of muscle tone, joint mobility, and sympathetic activity.[45] Gillette[46] hypothesized that a chiropractic lumbar thrust would produce sufficient force to coactivate all of the mechanically sensitive receptor types he reviewed, because it generates over 40 newtons of force. Adjustments made with the AAI are thought to accomplish the same task, because they have been reported to produce well over 40 N of force.[47] Brodeur[48] proposed that the AAI has the capacity to

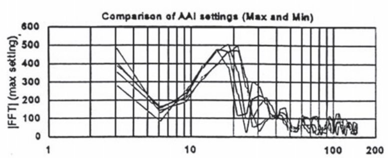
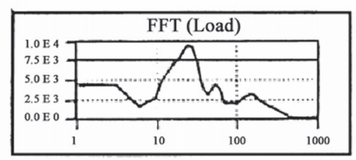
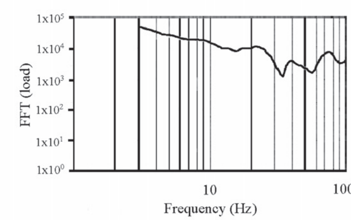
			
Date introduced	1976	1994	2000
Peak force	up to 150 N	up to 190 N	121 to 150 N
Time to peak force	3 ms	3 ms	3 to 5 ms
Controlled preload force	variable	variable	22 N
Force frequency profile			
Proportion of mechanoreceptor stimulation frequencies generated	35%	48%	74%

Fig. 1. Summary of the development of the Activator Adjusting Instrument. Source: (Charts, columns 1 and 2) Reprinted with permission from Keller TS, Colloca CJ, Fuhr AW, Validation of the force and frequency characteristics of the Activator™ adjusting instrument: effectiveness as a mechanical impedance measurement tool, *J Manipulative Physical Ther,* Vol. 22, No. 2, pp. 81 and 84, © 1999, Mosby, Inc.

coactivate type III, high-threshold mechanoreceptors. More recent research has shown that both types III and IV receptors in diarthrodial joints, as well as type II in paravertebral muscles and tendons are responsive to vertebral displacement.[48] It has also been shown that muscle activation is elicited by fast thrusts, not slow ones—regardless of joint cavitation sounds.[33,50] Figure 2 shows the range of frequencies generated from the AAI III as compared to the frequency threshold ranges of three major mechanoreceptors, the Merkel discs, and Meissner and Pacinian corpuscles.[51] AAI III improves force magnitude across the frequency thresholds, thus improving the possibility of neurological response of the adjustment.

Speed of the thrust, however, was found to be important in eliciting neural responses—regardless of the presence of cavitation. In a series of thoracic spinal thrusts producing audible joint cavitation, only fast thrusts produced electromyelogram activity in paraspinal musculature.[50] Herzog confirmed that cavitation alone is not responsible for back muscle reflex responses. In his study, magnitude of applied force was found to have little importance in bringing about a response in muscle reflexes.[36]

Increases in neurophysiological response to various directions of force vectors applied to mechanoreceptors are known as "receptive fields."[49,52–54] One study using the controlled force vectors of the AAI lent support to the importance of thrust direction, or line of drive. In this study, mixed spinal nerve discharge measured in response to an Activator adjustment delivered directly on lumbosacral vertebrae.[55] A patient volunteer was prepared for back surgery. An incision was made over the L3-S2 midline and the S1 nerve root was monitored at the dorsal root ganglion on the right side.

In phase I, an internal Activator adjustment was made directly to the mammillary process of L5. In the second phase, an Activator thrust was made to the skin and tissue overlying the spine at various locations. In both cases, a mixed nerve root response was measured. The research yielded several important findings. First, the Activator impulse traversed the soft tissue and elicited a mixed nerve response similar to direct thrust on bone. Second, sensitivity to direction of force was supported because an anterior superior line of drive increased mixed nerve response by as much as three times, supporting earlier research by Pickar and McLain.[54] Surprisingly external spinal manipulative thrusts caused a greater range of neural response in comparison to internal ones, especially when the line of drive was anterior superior in direction (Table 4).

Herzog and colleagues[36] investigated forces delivered to the spine with manual, high-velocity, low-amplitude (HVLA) adjustments. Manual manipulation produced relative movements in the target vertebra of 1 mm translation and 1 degree of rotation. This was comparable to vertebral movement effected by AAI. Herzog's group found that although total forces are greater with manual adjustments—because of the larger contact area—local peak or specific forces on the target

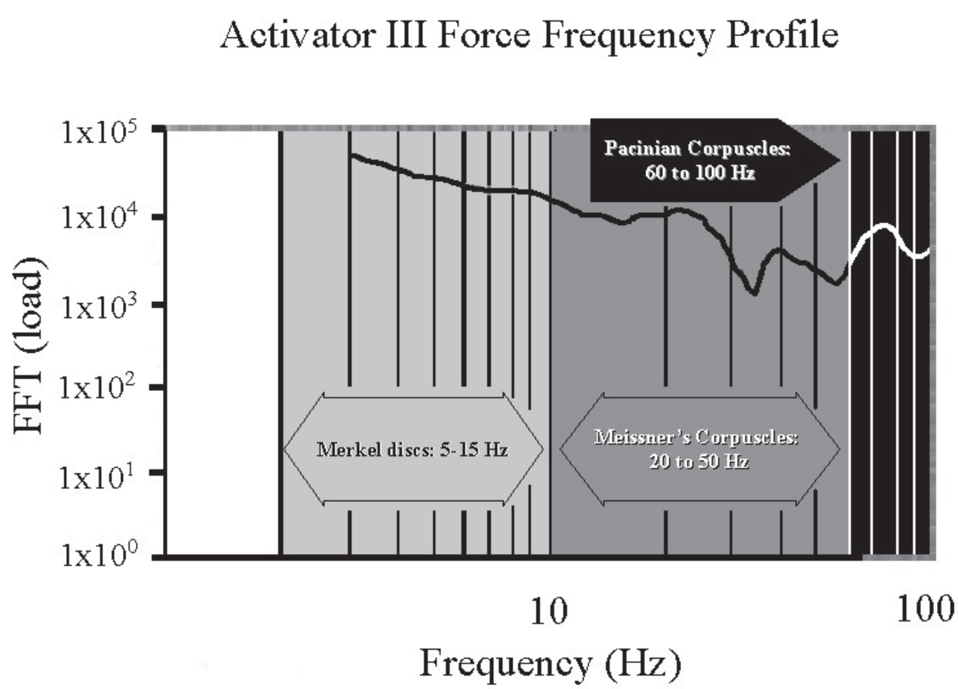


Fig. 2. Results of fast Fourier transform of Activator III force impulse

Table 4. Average mixed-nerve root responses (mV) to spinal manipulative thrusts delivered internally and externally at different segmental levels and with differing force vectors

	L5 Ant LOD	L5-Ant-sup LOD	S1-Ant-inf LOD
Internal spinal manipulative thrusts	500–1,200	1,200–2,600	200–900
External spinal manipulative thrusts	1,200	800–3,500	900

LOD indicates line of drive; Ant, anterior; Sup, superior; Inf, inferior.
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vertebrae itself are the same for Activator and hands only manipulation. They also found that hands-only manipulation delivers the peak force over 150 to 200 milliseconds. This compares to a delivery of about 3 milliseconds for the AAI.

In measuring neuromuscular responses of back muscles with surface EMGs in response to Activator treatment, Symons and colleagues[34] found about 68% of the thrusts resulted in a detectable response. Specifically, the cervical spine responded to 50% of the thrusts; thoracic spine, 59%; lumbar spine, 83%; and sacroiliac joints, 94%. Colloca and Keller[38] reported neuromuscular responses were elicited in 95% of the 20 low back patients from AAI adjustments. In this study, surface electromyographic electrodes monitored lumbar paraspinal muscles as they responded consistently to a modified Activator adjustment of specific vertebral segments. Another study of back pain patients found significant but temporary increases in trunk muscle strength as a result of AAI lumbosacral adjustments.[56] Neurological effects via vertebral displacement may extend beyond somatic pain and dysfunction, according to Bolton.[49] He noted some types of vertebral displacements modulate heart rate, blood pressure, and electrical activity in renal and adrenal nerves and in gastrointestinal muscles.

There are at least two components to the chiropractic adjustment: biomechanical and neurophysiological. Two major approaches for adjusting the spine are instrument and hands-only, and they appear to be effective via clinical experience. Some comparative clinical research is discussed in the next section. However, in terms of application to the body, hands-only and AAI are distinctly different. Table 5 compares the two approaches in terms of preload forces, adjustive forces, and thrust duration.[57]

CLINICAL RESEARCH

From a biomechanical perspective, AAI thrusts appear equivalent to hands-only. However, is the AAI adjustment therapeutically equivalent to manual adjusting in terms of clinical outcomes? Two studies have attempted to address this question by means of randomized clinical trials. Gemmel and

Table 5. A comparison of forces and thrust duration of Activator Adjusting Instrument III versus manual manipulation

Mode of adjustment		Spinal region: Cervical	Thoracic	Lumbosacral/sacroiliac
(AAI III)	Preload force	22 N	22 N	22 N
	Peak impulse force	121 N	123 to 150 N	125 to 150 N
	Impulse duration	3 to 5 ms	3 to 5 ms	3 to 5 ms
Manual manipulation*	Preload Preload force	0 to 50 N	139 ± 46 N	328 ± 78 N
	Peak impulse force	40 to 120 N	88 ± 78 N	399 ± 119 N
	Impulse duration	30 to 129 ms	150 ± 77 ms	150 ± 77 ms

Source: Data from Pickar JG. Neurophysiological effects of spinal manipulation. *The Spine Journal,* in press.

Jacobson[39] compared a single AMCT to a single manual adjustment in 30 acute low back pain patients. They found no significant differences in pain reduction between the two methods, though no control group was used to compare to natural history. Wood and colleagues[40] compared Activator adjusting to manual manipulation in the treatment of cervical spine dysfunction. The 30 patients who had neck pain and restricted range of motion were randomly assigned into two groups, one treated with an Activator II instrument, the other by manual HVLA diversified adjusting. At the end of the treatment period—a maximum of eight treatments or until asymptomatic status was reached—both groups experienced a significant decrease in symptoms. The AMCT group actually showed a greater improvement in cervical range of motion from pre- to posttreatment, and from posttreatment to 1-month follow-up, as compared to the diversified group. Also, the AMCT group experienced range of motion improvement in all directions, whereas the diversified group experienced improvement in left rotation. However, because neither study had control groups, and thus no comparison to natural history, interpretation as to either treatment efficacy must be made with caution.

Yates and colleagues[58] tested whether spinal adjustments to T1 to T5 subluxations could have an effect upon blood pressure and anxiety. Twenty-one subjects were randomly assigned to three treatment groups: adjustment (by AAI), placebo (AAI set to zero force), and baseline (no treatment) control. Subjects' systolic and diastolic blood pressures and anxiety were measured. All groups were equivalent in their pretreatment scores and stable in blood pressure measurements from baseline to pretreatment evaluation. Analysis of change scores from pre- to posttreatment showed significant differences between the three groups with respect to decreases in systolic, diastolic, and state anxiety. Specifically, systolic and diastolic pressures were reduced only in the Activator treatment group. State anxiety was reduced more in the Activator treatment group, but this decrease was not significantly different from the control.

In another study,[59] 10 consecutive new patients with a history of neck injury and 9 asymptomatic volunteer controls were subjected to a regime of mechanical force manually assisted short lever chiropractic adjustments from an AAI. Although acute, 4 of the 10 also received interferential electrical stimulation current to the rhomboids. Visual analog scales measured pain whereas dysfunction was measured by finite helical axis parameters (FHAP) that closely mirrored the clinical condition of patients. The FHAP patterns in the treatment group differed markedly from FHAP patterns observed in the asymptomatic control group for all but one of the patients. After 6 weeks, the mean pain scores decreased and function increased significantly over the course of treatment in comparison to the control group ($p < 0.001$ for pain and $p < 0.001$ for FHAP). After 1 year, 7 of the 10 treated patients noted stability of their symptoms at or near the level reported immediately after the 6-week treatment period.

In a small randomized trial, 14 patients with neck pain randomly were assigned to either manual therapy or Activator treatment. Both groups saw an appreciable but not statistically significant reduction in pain and increase in range of motion. However, there were no differences between the Activator and hands-only adjusting in terms of pain and function outcomes.[44] Yet another case series of 10 patients under Activator management had a significant reduction of pain in a chronic sacroiliac joint syndrome. Under this study, a 6-week regimen of AAI adjustments reduced pain from mean baseline values of 25 to 12, and average disability scores diminished from 28% to 13% (both $p < 0.05$).[60]

Randomized, placebo-controlled clinical trials should have, among other attributes, a comparison treatment similar to the treatment intervention except for an "active ingredient" believed to be responsible for clinical change. In the case of spinal manipulation or adjustment, this is the thrust delivered to the spinal site indicated by the chiropractic system of analysis. With manual adjustment studies, sham placebos are difficult to design because they are often not similar enough to the actual manipulation. The AAI, on the other hand, lends itself easily to controlled clinical trials because of its ability to reduce force transmission to zero while giving the appearance and sound of an actual Activator adjustment. Several investigators have highlighted the usefulness of the Activator in clinical research.[56,61] Chiropractic for the first time has a widely used clinical intervention readily adaptable to the research setting.

Case series and case studies

Two types of observational studies are of special interest to clinicians: individual case studies and clinical series. The former examines a single patient in depth; the latter is an accumulation of individual patients measured on the same outcomes. Case studies have many limitations in validity, but are useful for illustrating clinical phenomena and for introducing research hypotheses.

Polkinghorn and Colloca[62] reported an apparently successful treatment for unremitting coccygodynia of 3 weeks duration in a 29-year-old female. Isolation tests of the sacrococcygeal region indicated the coccyx had subluxated laterally. Significant relief was appreciated after the very first Activator treatment: an adjustment near the base of the coccyx performed as indicated by AMCT analysis protocol prescribed contact and specified line of drive. The patient was treated until the leg checks indicated her problem had resolved.

Case studies have suggested successful resolution of lumbar disc herniation signs and symptoms[63] and cervical disc protrusion signs and symptoms[64] by AMCT management. In the latter case, a 42-year-old woman with cervical disk protrusion unresponsive to manual manipulation showed a "favorable" response during the first week of AMCT management. All signs and symptoms resolved by the end of 3.5 months.

Other case studies have shown promise for AMCT analysis. The treatment of a torn medial meniscus,[65] plantar fasciitis attributed to posterior calcaneus subluxation,[66] otitis media when related to upper cervical segmental dysfunction,[67] Bell's palsy,[68] adhesive capsulitis (frozen shoulder),[69] postsurgical neck syndrome,[70] chest pain,[71] acute torticollis,[72] and sciatic neuropathy and low back pain associated with lumbar disc herniation.[73,74]

SAFETY

When any novel health care device is employed, safety is a primary concern and must be satisfactorily established. Thus the first NIH grant ever awarded for chiropractic-related research investigated the safety and efficacy of spinal manipulation by use of an adjusting instrument. The goal of the research was to investigate the safety of the AAI, an adjusting instrument with an internal hammer hitting a stylus. Articles produced from the grant found that the spring driving this hammer could not have produced more than 0.3 J of potential energy to be effective but safe. In testing, the AAI was found quick to complete a thrust, but yet never achieved great velocity because of the short distance traveled.[24,25]

In a survey of chiropractors in Denmark on the safety of cervical adjustments, upper cervical rotational adjustments appeared to pose a greater risk for cerebrovascular accidents or cerebrovascular incidents.[75] The authors suggested that AAI adjusting was not involved in any adverse incidents in the Danish chiropractic patients. It was inferred that AMCT is an acceptable form of chiropractic treatment in cases in which rotation is contraindicated.[76] This idea was lent some support by Kawchuk and Herzog,[77] in which five chiropractic treatment types were compared. Activator adjusting exhibited a low peak force and the lowest thrust duration.

As with any intervention with therapeutic potential, risks exist. Nykoliation and Mierau[78] published a review of three alleged injury cases in Canada possibly associated with mechanical adjusting devices, though neither the AAI nor AMCT analysis was identified. The single reported case of stroke was subsequent to a motor vehicle accident with headaches and neck pain and included multiple modalities of cervical traction, diathermy, and conventional spinal manipulation in patient management. With the accident and other treatments, a clear causal link to mechanical adjusting was not established. Two other cases included a patient with thoracic pain treated by a mechanical adjusting device accompanied by "twisting motions" inconsistent with AMCT protocols, and another with neck pain, headaches, and right arm paraesthesias unresponsive to a mechanical adjusting instrument, but who subsequently responded to manual adjusting.

CONCLUSION

Instrument adjusting has a long history preceding the chiropractic profession. The AMCT was initially developed as an outgrowth of the "thumb-thrust" technique, a type of low force adjustment. Later the technique incorporated and modified Derifield leg length checks as a primary clinical indicator. AMCT has been a leader in chiropractic research with at least 54 studies related to the biomechanics, neurophysiology,

Table 6. Summary table of Activator prospective group trials

Colloca CJ, Keller TS. Electromyographic reflex responses to mechanical force, manually assisted spinal manipulative therapy. *Spine.* 2001;26(10):1117–1124.

Colloca CJ, Keller TS. Stiffness and neuromuscular reflex response of the human spine to posteroanterior manipulative thrusts on patients with low back pain. *J Manip Phys Ther.* 2001;24(8):489–500.

Gemmell HA, Jacobson BH. The immediate effect of Activator vs. meric adjustment on acute low back pain: a randomized controlled trial. *J Manip Phys Ther.* 1995;18(7):453–456.

Keller TS, Colloca CJ, Fuhr AW. In vivo transient vibration assessment of the normal human thoracolumbar spine. *J Manip Phys Ther.* 2000;23(8):521–530.

Keller TS, Colloca CJ. Mechanical force spinal manipulation increases trunk muscle strength assessed by electromyography: a comparative clinical trial. *J Manip Phys Ther.* 2000;23(9):585–595.

Nathan M, Keller TS. Measurement and analysis of the in vivo posteroanterior impulse response of the human thoracolumbar spine: a feasibility study. *J Manip Phys Ther.* 1994;17(7):431–441.

Osterbauer PJ, DeBoer KF, Widmaier RS, et al. Treatment and biomechanical assessment of patients with chronic sacroiliac joint syndrome. *J Manip Phys Ther.* 1993;16(2):82–90.

Osterbauer PJ, Derickson KL, Peles JD, et al. Three-dimensional head kinematics and clinical outcome of patients with neck injury treated with spinal manipulative therapy: a pilot study. *J Manip Phys Ther.* 1992;15(8):501–511.

Wood TG, Colloca CJ, Matthews R. A pilot randomized clinical trial on the relative effect of instrumental versus manual thrust manipulation in the treatment of cervical spine dysfunction. *J Manip Phys Ther.* 2001;24(4):260–271.

Yates RG, Lamping NL, Abram C, et al. The effects of chiropractic treatment on blood pressure and anxiety: a randomized, controlled trial. *J Manip Phys Ther.* 1988;11(6):484–488.

Table 7. Summary table of Activator Methods case studies

Frach JP, Osterbauer PJ. Chiropractic treatment of Bell's palsy by Activator instrument adjusting and high voltage electrotherapy: a report of two cases. *J Manip Phys Ther.* 1992;15(9):596–598.
Henningham M. Activator adjusting for acute torticollis. *Chiropr J Austr.* 1982;2:13–14.
Phillips NJ. Vertebral subluxation and otitis media: a case study. *Chiropractic.* 1992;8(2):38–39.
Polkinghorn BS. Chiropractic treatment of frozen shoulder (adhesive capsulitis) utilizing mechanical force, manually assisted short lever adjusting procedures. *J Manip Phys Ther.* 1995;18(2):105–115.
Polkinghorn BS. Conservative treatment of torn medial meniscus via mechanical force, manually assisted, short lever chiropractic adjusting procedures. *J Manip Phys Ther.* 1994;17:474–484.
Polkinghorn BS. Grand rounds discussion: patient with acute low back pain. *Chiropr Tech.* 1999;11(1):1–32.
Polkinghorn BS. Instrumental chiropractic treatment of frozen shoulder associated with mixed metastatic carcinoma. *Chiropr Tech.* 1995;7(3):98–102.
Polkinghorn BS. Posterior calcaneal subluxation; its importance in conservative treatment of heel spur syndrome (plantar fasciitis) via instrumentized chiropractic adjusting procedures. *J Chiropr Sports Med.* 1995;9(2):44–51.
Polkinghorn BS. Treatment of cervical disc protrusion via instrumental chiropractic adjustment. *J Manip Phys Ther.* 1998;21(2):114–121.
Polkinghorn BS, Colloca CJ. Chiropractic treatment of coccygodynia via external instrumental adjusting procedures utilizing Activator Methods Chiropractic Technique. *J Manip Phys Ther.* 1999;22(6):411–416.
Polkinghorn BS, Colloca CJ. Chiropractic treatment of postsurgical neck syndrome utilizing mechanical force, manually-assisted short lever spinal adjustments. *J Manip Phys Ther.* 2001;24(9):589–595.
Polkinghorn BS, Colloca CJ. Treatment of symptomatic lumbar disc herniation utilizing Activator Methods Chiropractic Technique. *J Manip Phys Ther.* 1998;21(3):187–196.
Richards GL, Thompson JS, Osterbauer PJ, Fuhr AW. Low force chiropractic care of two patients with sciatic neuropathy and lumbar disc herniation. *Am J Chiropr Med.* 1990;3(1):25–32.
Yurkiw D, Mior S. Comparison of two chiropractic techniques on pain and lateral flexion in neck pain patients: a pilot study. *Chiropr Tech.* 1996;8:155–162.

clinical assessment reliability, and clinical outcomes (Tables 6 and 7). AMCT also has led in organizing and codifying an approach to chiropractic care by publishing a comprehensive textbook on the subject.[79]

The first Activator training seminar was offered in 1969, and has grown to 32 seminars per year, with certification of more than 1,500 chiropractors in Activator Methods basic technique and 600 chiropractors in the advanced technique. Recent data from the National Board of Chiropractic Examiners find the Activator technique the most used name-brand technique in use by chiropractors, with 63% of chiropractors claiming use on about 22% of their patients in 1998. AMCT appears to be among the fastest growing, with a 24% growth in chiropractic usage between 1991 and 1998.[1]

Activator Methods chiropractic technique offers spinal and extremity adjusting with clear training and competency standards and objectives. In studies, the AAI and AMCT results are similar to hands-only adjusting procedures. Force-delivery characteristics and lines-of-drive are along planes of joint without segment rotation, which may reduce risk of unintended and iatrogenic effects of spinal manipulative therapy for high-risk patients.

As with all chiropractic science and technique, the AMCT must address issues of clinical efficacy and cost-benefit to address the demands of quality health care in the future and help define chiropractic's role in the future of health care delivery.

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