Status of Activator Methods Chiropractic Technique, Theory, and Practice

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Abstract

Objective: To provide an historical overview, description, synthesis, and critique of the Activator Adjusting Instrument (AAI) and Activator Methods Chiropractic Technique of clinical assessment.

Methods: Online resources were searched including Index to Chiropractic Literature, EBSCO Online, MANTIS, CHIROLARS, CINAHL, eJournals, Ovid, MDConsult, Lane Catalog, SU Catalog, and Pubmed. Relevant peer-reviewed studies, commentaries, and reviews were selected. Studies fell into 2 major content areas: instrument adjusting and the analysis system for therapy application. Studies were categorized by research content type: biomechanical, neurophysiological, and clinical. Each study was reviewed in terms of contribution to knowledge and critiqued with regard to quality.

Discussion: More than 100 studies related to the AAI and the technique were found, including studies on the instrument's mechanical effects, and a few studies on clinical efficacy. With regard to the analysis, there is evidence for good reliability on prone leg–length assessment, but to date, there is only 1 study evaluating the Activator Methods Chiropractic Technique analysis.

Conclusion: A body of basic science and clinical research has been generated on the AAI since its first peer-reviewed publication in 1986. The Activator analysis may be a clinically useful tool, but its ultimate scientific validation requires testing using sophisticated research models in the areas of neurophysiology, biomechanics, and statistical analysis.
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Key Indexing Terms: *Chiropractic; Research; Education*

In 2003, Activator Methods Chiropractic Technique (AMCT) was 35 years old, and we pause to look at where we are and where we should go from here. The early years of this method are related elsewhere in detail.[1-3] As well, the technique has been described in terms of its protocols and clinical objectives in previous publications.[1,4,5] This paper concentrates on the recent trends in AMCT theory, technique, and training.

Kaminski et al articulated a methodology for evaluating chiropractic techniques.[6] Cooperstein[3] noted that AMCT was the first and to that time possibly the only, technique system to apply the Kaminski framework for technique validation.

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Methods

A literature search was performed in July 2003. A digital search was conducted using keywords: "Activator," "instrument and adjusting," "instrumentation," "manual adjusting devices," "instrument adjusting," and "chiropractic." " Databases searched were Index to Chiropractic Literature, EBSCO Online, MANTIS, CHIROLARS, CINAHL, PubMed, eJournals, Ovid, MDConsult, Lane Catalog, and Stanford University Catalog. The materials were reviewed and compiled into a narrative review.

Discussion

Early Theory

The AMCT had a relatively empirical, although not completely theoretical, embryology. Cofounders Warren C. Lee, DC, and Arlan W. Fuhr, DC, had studied the hypotheses of Hugh B. Logan, DC, and his Basic Technique.[7] Subluxation and its presumed effects were central to Lee's and Fuhr's emerging procedures of evaluation and adjusting. As well, a holistic view of the spine and its coordinated function was adopted. The leg-check procedures of the Derefield were added for pragmatic reasons; that is, to provide an immediate "snapshot" of dysfunction and distortion status after adjustments and to lessen dependence upon radiography and its attendant risks. Subluxation-derived rotation of the pelvis was thought to be the most proximal cause for functional leg-length inequalities. Clinical indicators–called isolation tests, stress tests, and pressure tests were developed by informal clinical observations. In lieu of the thumb thrusts, adopted from Van Rumpt's Direct Nonforce Technique, Lee and Fuhr sought a less physically taxing means of producing adjustive thrusts to specific vertebrae. The Activator Adjusting Instrument (AAI), derived originally from a dental impactor and now in its third generation, is the latest product of that search.

Technique

The AMCT methodology may be divided into assessment and intervention procedures. These 2 aspects are not mutually dependent: the one may be used without the other. Activator Methods International (AMI), Ltd, offers both sets of procedures and requisite materials as an integrated whole.

AMCT Analysis

The theory behind AMCT evaluation methods include the articular dysfunctions believed to mediate a wide range of health problems. These dysfunctions have been termed the "subluxation complex," a component of the broader "subluxation syndrome."[8] The AMCT analysis is based on the assumption that faulty biomechanical behavior of articulations is reflected in differences and changes in leg lengths. The assessment protocol prescribes a series of prone leg–length observations and provocative tests to evaluate the function of joints from the feet progressively upward to the cervical spine. It is believed that dysfunction of more caudal segments must be "cleared" (ie, the lesion be removed or reduced by adjusting) before more rostral structures can be properly evaluated. The protocol has both theoretical and empirical roots. Initially derived from the leg-check concepts of Van Rumpt, the Derefield[9] and other various isolation, pressure, and stress tests have largely evolved from the clinical experience of Activator practitioners.

The assessment involves repeated systematic observations of the relative leg lengths (legs extended or "position 1") and apparent changes in the leg lengths (flexed knee or "position 2") while the patient lies prone. These multiple observations are made before and after each of a series of provocative maneuvers including isolation testing, pressure testing, stress tests, and location of vertebra-specific thrusts (adjustments).

"Isolation tests" are maneuvers performed actively by the patient for stimulating subtle muscular changes in the body, perhaps via mechanoreceptors in muscles, diarthrodial joints, ligaments, or tendons associated with the axial and appendicular skeleton. In the presence of articular dysfunction, specific movements in combinations of rotation, flexion-extension, and abduction-adduction are hypothesized to provoke specific neuromuscular irritations and contractions, which in turn appear to manifest in leg-length changes in a consistent manner.[10,11] The reaction of the initially shorter leg in position 1 (designated the "PD leg" for the "pelvic deficiency" thought to produce the functional short-leg phenomenon) is believed to indicate the presence or absence of subluxations somewhere in the body.

"Stress tests" are applied by the doctor's forefinger or thumb to accentuate the suspected dysfunction or subluxation, as indicated by leg-length inequality. The force is applied in the direction of subluxation. If no change in apparent leg length is observed, the target area is considered free of dysfunction; further shortening of the PD leg in position 1 is considered an indicator of subluxation.

Conversely, "pressure tests" involve gentle digital force applied to the suspected subluxation in a direction of correction. This vector is applied to temporarily "reduce" the positional misalignment or dynamic dyskinesia of a vertebral joint. With a pressure test, the leg-length inequality is expected to balance.[12]

Investigations of AMCT analysis

The AMCT analysis is performed in successive stages; evaluation and treatment of lower or caudal lesions are given precedence over more rostral ones. This notion is an extension of the Logan Basic Technique concept of the importance of the sacrum and pelvis as biomechanical foundations for the rest of the spine. Investigations of the reliability and validity of AMCT analysis, therefore, should take into account the "layered" nature of this approach to subluxation detection.

Activator analysis is intended to give specific indications for patient treatment protocol and completion of treatment and constitutes a major focus of the AMCT training. Although there may be some agreement about the clinical utility of these procedures among many practitioners, expert opinion is not sufficient to validate this method of subluxation-detection. Accordingly, AMI has been concerned with quantitative studies that provide critical empirical information about these assessment methods.

Reliability of leg-length evaluations. Several studies have investigated the reliability of the common denominator found in isolation tests, pressure tests, and stress tests, which are the relative leg-length observations. Most investigations have evaluated interexaminer reliability in position 1 (Table 1), and all have indicated good agreement for this type of observation. However, 2 studies reported data which do not permit judgments about agreement beyond chance.[13,14] DeBoer et al[15] studied 40 chiropractic freshmen who were "free of any known neurological or musculoskeletal defects." The students found good to excellent intra-examiner and weaker interexaminer reliability among experienced clinicians who measured prone, extended leg–length differences at the heel-sole interface in millimeters. Rhudy and Burke[16] found "poor" to "substantial" concordance

Table 1. *Characteristics of several studies of the intraexaminer and interexaminer reliability of leg-length evaluations in the prone extended position (position 1)*

Authors, date	Subjects	Examiners	Design and statistics	Findings and limitations
Venn et al[14] (1983)	30 Nonacute patients	20 Chiropractic interns and clinic tutors	3 Repeated leg-length observations reported as number of examiners who found right short, left short, or even legs; % agreement and χ^2 values computed	Concordance beyond chance among observers cannot be determined from raw data reported nor from inferential statistics provided
DeBoer et al[15] (1983)	40 Chiropractic freshmen, age 21-35 y	3 Chiropractic clinic faculty members	Each subject measured twice by each examiner for leg-length difference in millimeters; concordance evaluated by ICCs	ICCs for interexaminer reliability were 0.23 (ns), 0.32 ($P < .05$) and 0.37 ($P < .05$); ICCs for intraexaminer concordance were 0.52, 0.70, and 0.77 ($P < .05$ in all cases); measurement system differs from AMCT
Andrew and Gemmell[17] (1987)	18 Patients with normal gait, age 7-70 y	4 Chiropractors experienced in leg checks	Each patient examined by 4 blinded examiners; "mean pairwise agreement" and "mean chance agreement" computed for trichotomous choice	Mean pairwise agreement was 69%; mean chance agreement was 52%; κ not reported but can be estimated as $\kappa = 0.35$
Shambaugh et al[13] (1988)	26 Chiropractic freshmen; 10 with no prior adjustments	5 Chiropractors	5 Repeated recordings of millimetric differences in prone leg lengths recorded with head positioned center, right rotated, and left rotated	Concordance beyond chance among observers cannot be determined from raw data reported nor from inferential statistics provided
Fuhr and Osterbauer[18] (1989)	30 Activator instructors	4 Activator instructors, with approximately 10-y experience each; all AAPR	Interexaminer concordance for trichotomous findings (left short, even, or right short leg) assessed by unweighted κ in 6 pairwise comparisons; interexaminer concordance for absolute differences in leg lengths assessed by pairwise and 4-examiner ICC	κ Pairwise values ranged from 0.31 to 0.75 (all significant at $P < .05$ or better); no agreement on "even" legs; ICC overall concordance was 0.59 ($P < .05$); pairwise ICC comparisons were generally weaker, ranging from 0.14 to 0.71; order of examiners was not randomized, and examiners were familiar with subjects
Rhudy and Burke[16] (1990)	Study 1: 19 patients	3 Nonexpert examiners	Interexaminer concordance for "discrepancy in leg length" according to Thompson Technique, assessed by κ coefficient	"Poor" to "substantial" concordance, but unit of analysis is unclear
	Study 2: 22 patients	3 Expert examiners	Interexaminer concordance for "discrepancy in leg length" according to Thompson Technique, assessed by κ coefficient	"Moderate" to "substantial" concordance, but unit of analysis is unclear
Nguyen et al[19] (1999)	34 Patients: 23 women and 11 men, age 28-88 (mean 58) y	2 Activator instructors, both AAPR	Interexaminer concordance for trichotomous findings (left short, even, or right short leg) assessed by unweighted κ; reanalysis of dichotomous findings (excluding 2 cases where "even" legs observed) by unweighted κ	3×3 Unweighted $\kappa = 0.66$ ($P < .001$); no agreement on "even" legs; reanalysis by 2×2 κ produced similarly strong agreement beyond chance

The study of reliability of isolation testing by Youngquist et al[20] is excluded from this table because it involved testing leg lengths in position 2. *AAPR*, Activator advanced proficiency-rated.

beyond chance in a trial involving 3 nonexpert examiners using Thompson Technique procedures and "moderate" to "substantial" agreement beyond chance when 3 expert examiners observed for leg-length discrepancy. All subjects were identified as patients. However, inadequate description of procedures and units of analysis in this report limits its interpretability.

Three studies have explored the interexaminer reliability of leg-length evaluations as performed in AMCT. Andrew and Gemmell[17] supervised 4 chiropractors experienced in AMCT leg checks, who examined 18 patients with "normal gait," ages 7 to 70 years. They found that observed agreement (69%) exceeded chance agreement (52%); the κ statistic for concordance may be estimated from these figures as $\kappa = 0.35$ (ie, "fair" agreement). Fuhr and Osterbauer[18] used 4 Activator instructors to examine the leg lengths of 30 other Activator instructors. They found marginal to excellent concordance beyond chance for trichotomous observations (left short, right short, or even leg lengths) and weaker inferential coefficients of agreement for millimetric recordings of the differences between right versus left heel-sole interfaces. Unfortunately, methodological problems hamper interpretation of these findings. These weaknesses included a lack of randomization of the order of examiners and the vocal report of the short-leg side in the presence of the subject.

Nguyen et al[19] used 2 Activator instructors to examine 34 patients for relative leg lengths; the order of examiners was randomly assigned, and the recording process was silent. Inferential analysis (unweighted $\kappa = 0.66$, $P < .001$) revealed good agreement beyond chance and was in the midrange of the concordance coefficients reported by Fuhr and Osterbauer.[18] Once again, findings of even legs were uncommon, and there was no agreement between examiners for this category of observation.

With the exception of DeBoer et al,[15] all of these investigations have evaluated the interexaminer reliability of leg checks in the prone, extended position only; the reliability of AMCT leg-length evaluations in position 2 (flexed knee) has yet to be studied. However, DeBoer et al found strong intraexaminer reliability (intraclass correlation coefficients [ICCs] varied from 0.64 to 0.69, $P < .05$ in all instances) among clinicians who measured apparent leg-length differences with knees flexed. Weaker coefficients were found for pairwise interexaminer concordance in position 2: ICC = 0.06 (ns), 0.30 ($P < .05$), and 0.34 ($P < .05$). These findings involved ratio-scale data (millimeters). It should also be noted that AMCT leg-length evaluations in position 2 are not merely judgments of relative leg lengths, but rather intend to judge change in the apparent length of the PD leg from position 1 to position 2. Although such information might be extrapolated from DeBoer et al's raw data (eg, by converting millimetric data to a dichotomous scale and looking for change in side of relative short-leg length from position 1 to position 2), the observation task itself differs from that used in the AMCT protocol.

Youngquist et al[20] studied examiners' ability to agree on a segmental level of a presumed lesion (subluxation) based on isolation testing. Although not an assessment of position 2 leg check reliability, this study offers indirect support of the idea that examiners can agree on this component of the AMCT assessment procedure.

The reliability of AMCT leg lengths in position 1 appears to be adequate. The most methodologically sound leg-length reliability study[19] involved a patient sample and found agreement beyond chance that paralleled findings in other studies involving weaker methodology and nonpatient samples.[17,18] Findings for the AMCT method of leg-length evaluation also parallel those for other non-AMCT leg check procedures.[15,16] However, the reliability of AMCT leg checks made in position 2 has yet to be directly evaluated.

Pressure testing. The only studies to directly address the reactivity of leg-length changes in response to articular pressure testing and adjusting (at various segmental levels) did not find consistent changes in leg lengths.[21,22] Haas et al[21,22] used 42 symptomatic and asymptomatic students, faculty, and staff members of a chiropractic college as subjects. They concluded that leg-length changes in response to pressure testing and adjusting constitute a "diagnostic illusion." However, several design limitations may inhibit full interpretation. These included the small number of subjects who "met the eligibility criterion for adjustment" (n = 6), the unevenness that random assignment may have produced across groups, and an unusual lack of "stability" (ie, test-retest reliability) observed in several phases of the studies. Nonetheless, these papers challenge the utility of articular pressure testing and merit further investigation.

Isolation testing. Good reproducibility was found in a study of the interexaminer reliability of isolation testing to detect the presence or absence of joint dysfunction at C1.[20] Youngquist et al recruited patients with (n = 34) and without (n = 38) histories of adjustment at C1, who were examined by 2 clinicians "experienced in leg-length testing procedures and the application of the isolation test." Although experienced with the method, the clinicians did not rehearse the isolation tests together in unblinded fashion before the trial. Evaluation and intervention at all indicated segments below the atlas were conducted in each patient before designated examiners conducted the isolation maneuver (ie, chin tuck) for the first cervical segment. Two examination sessions on separate days yielded 2 samples (n = 24 and n = 48); concordance beyond chance for the dichotomous decision was $\kappa = 0.52$ ($P < .01$) for the first sample and $\kappa = 0.55$ ($P < .001$) for the second, indicating better than chance agreement between clinicians for this assessment procedure.

Another study involved millimetric measurement of leg-length differences by 5 clinicians while subjects' heads were centered, rotated right, and rotated left. Shambaugh et al[13] reported, "All raters found highly significant differences in LLI [leg-length inequality] when the head positions changed ($P < .001$)." Unfortunately, the nature of the inferential statistical test they used was unclear. Whether these findings are comparable to the trichotomous (short, long, or even leg lengths) observations made by clinicians is also uncertain.

Falltrick and Pierson[23] studied the responsiveness of leg lengths to several provocations. They found no changes in leg lengths when subjects were asked to rotate their heads while a blinded examiner measured leg lengths in millimeters. These recordings were produced by noting distances along a meter stick extending from a pedestal placed on the subject's midlumbar region to the ankles. Neither were there any significant differences in leg-length inequality among subjects identified as "cervically lesioned" (by independent methods, palpation, etc.) versus those without these presumed dysfunctions. Although subjects were able to produce observable changes in leg lengths when requested to voluntarily "hip hike," unilateral electromuscular stim-

Table 2. *Values of κ coefficients and corresponding adjectives used by Rhudy and Burke*[16]

κ Value	Adjective	κ Value	Adjective	κ Value	Adjective
<0	None	0.21-0.40	Fair	0.61-0.80	Substantial
0.00-0.20	Poor	0.41-0.60	Moderate	0.81-1.00	Almost perfect

ulation of the midthoracic and midlumbar regions did not produce significantly different leg lengths despite observable tetanic contractions in the areas stimulated.

Another laboratory evaluation of isolation testing[24] involved "optoelectric" measurement of heel position changes during cervical maneuvers, including resting, neck extensions, and chin tucks. In response to prone neck extension, greater asymmetrical movements between legs were observed in subjects with chronic spinal complaints than in asymptomatic controls. Whether the recorded phenomenon is comparable or related to that observed by clinicians is unclear but merits further scrutiny.

Rhudy and Burke[16] found "fair" to no concordance beyond chance among 3 nonexpert examiners who observed for leg-length discrepancies according to the Thompson Technique procedures in 19 patients during right and left head rotations. A second sample of 22 patients was evaluated for leg-length discrepancy by 3 "expert" examiners during the same isolation maneuvers; "poor" to "moderate" agreement beyond chance was reported. Unfortunately, the units of analysis (eg, 2-choice vs 3-choice observations) were not given. Exact κ values and associated probabilities were not stated; instead, adjectives were applied to κ values according to the schedule shown in Table 2.

Taken together, these 5 studies[13,16,20,23,24] are still insufficient to substantiate the validity of AMCT isolation testing. However, several additional comments are in order. The report of Shambaugh et al,[13] which suggests the responsiveness of relative leg lengths to head positioning, must be challenged for the lack of clarity of data analysis. Rhudy and Burke's investigation did not consider reactivity of leg lengths to head motions but explored variations in reliability as a function of head position. As well, their project[16] made use of both instrumental and Thompson Technique methods of assessment and did not indicate the units of analysis (eg, dichotomous vs trichotomous leg–length findings). DeWitt et al[24] found that prone leg lengths did change in response to various neck and head movements, as measured by optoelectrical equipment. Further investigation is required to verify if the clinicians' prone leg check can be equated to the laboratory measuring procedure.

Similarly, there were considerable procedural variations between Falltrick and Pierson's[23] methods and those used in AMCT (eg, ratio data vs AMCT dichotomous observations, lack of cephalad pressure applied to the feet before measurement, no adjustments below the cervical spine before conducting cervical maneuvers).

Although Youngquist et al[20] showed moderate levels of agreement beyond chance among observers for cervical segmental dysfunctions, this paper should be considered provocative rather than conclusive. This report experimentally addresses the responsiveness of leg lengths to isolation maneuvers. As the only example of a direct evaluation of AMCT's isolation methods, it may provide a model for further investigation.

Future inquiry into AMCT assessment. Available data do not permit assertions concerning the validity of AMCT assessment procedures for the detection of supposed joint lesions or targets for adjustive intervention. Even so, the analysis system continues to be taught and used, as it is said to be a clinically useful aid in directing Activator treatment by Activator-trained practitioners. Even so, the subtle clinical assessment by Activator analysis must be an area for future research. As with any chiropractic technique, today's evidence-based climate requires investigation with regard to safety, efficacy, patient satisfaction, and cost. The contribution of Activator analysis could be explored by 2 general linear models: a factorial design with Activator analysis as 1 level of independent variable and multiple regression with the Activator analysis as a predictor variable contributing to clinical cost and outcome as criterion variables. Either or both of these research strategies can be added as a treatment arm in future research of any chiropractic technique.

Research Pertaining to Treatment

Several categories of research investigations into the effects of AMCT intervention merit review; these are technical reports (describing the physical characteristics of the instrument), physiological (biomechanical and neurological) studies, case reports, clinical series, randomized clinical outcome trials, ratings by clinical experts, and utilization studies. Safety and physical characteristics of the AAI are also areas of investigation, in light of the safety concerns of general cervical manipulation.[25,26]

Physical characteristics of AAI. Considerable effort has been directed to studying the physical characteristics of AAI adjustments. Duell[27] provided the first published report of the force of the first AAI. Subsequent investigations have led to several modifications of the AAI. A noteworthy National Institutes of Health–funded project in 1985—the first such grant ever awarded for a chiropractic research project—was designed to assess the device's safety and its effect on the body. Results[28,29] revealed that the instrument produced a maximum of 0.3 J of kinetic energy, enough to produce relative movement of vertebrae, but far below energies that could produce injury. When Kawchuk and Herzog[30] compared 5 chiropractic treatment methods, they found that Activator adjusting exhibited relatively low peak forces and the lowest thrust duration among the techniques studied. AAI thus appeared to represent a relatively low risk of injury, because of the small amplitude and brief 3-millisecond excursion.

One review described early studies[31] attempting to identify risk factors in cervical adjustments: rotary head movements during the manipulation, smoking, hypertension, oral contraceptives, patient age, and migraine headaches. In these retrospective reviews, only 1 reported an accident with instrument adjusting.[31] Ernst[32] continued to implicate the rotational component of high-velocity low-amplitude (HVLA) adjustment as a prime cause in cerebrovascular accidents. The survey of Danish chiropractors from 1978 to 1988 by Klougart et al[33] found double the incidence of CVI when rotational adjusting procedures were involved in cervical manipulation. An earlier publication by Klougart et al[34] found AAI adjusting to not be involved in either cerebrovascular accidents (CVA) or cerebrovascular incidents (CVI) incidents among Danish patients between 1978 and 1988. These findings could reinforce the notion that AMCT may be a good choice for patients at risk for HVLA.[35] However, with self-selection errors, nonrandom assignment, and a multitude of weaknesses in retrospective analysis, causality could not be properly ascribed to method or mode of delivery.

Nykoliation and Mierau[36] reported 3 AAI adverse outcomes. These included worsening of whiplash-associated shoulder and thoracic spinal pain in a 32-year-old woman; a 48-year-old woman with an unremitting 18-month history of neck pain, headaches, and right arm paresthesia; and a 36-year-old woman experiencing a stroke after a traumatic autoinjury that included manual therapy along with instrument adjusting. Other potential causes of harm in addition to instrument adjusting were noted. Causal attributions of harm from AAI adjustments could not be made in these reports. They further cautioned, "No effective treatment for patients with spinal disorders is completely without risk." Gleberzon[37] concurred, ". . .each case (of injury) involved issues not unique to the use of nonmanual procedures." All of the above point to current findings that causality may be a function of events other than treatment. Indeed, recent reviews suggest that CVIs and CVAs are rare, random, and unpredictable[38] and possibly independent of treatment.

Biomechanical research. Musculoskeletal biomechanical research addresses the structure and physical properties of muscle, tendon, ligament, capsule, cartilage, and bone under the effects of loading, unloading, and transmission of adjustive forces to the body. The natural resonant frequency of the spine, tissue compliance (stiffness), response to input force (impedance), and comparison to other types of adjustment have been areas of inquiry for AAI research.[30,39]

Evidence suggests that certain vibratory frequencies have the ability to promote healing or inflict harm.[40-43] Dynamic mechanical stimuli (vibration) that more closely match natural resonance of body tissues are conducted more efficiently through the body.[44] The effective transmission of adjustive forces may be a result of matching spinal resonant frequencies in addition to force magnitude and amplitude. The same amount of work could be accomplished with less force, when applied at resonant frequency. Under principles of structural mechanics, when resonant frequency of a structure is achieved, forces that induce movement are transmitted farther and in some instances even magnify movement, distal to the application of force. Researchers and practitioners of low-force technique, such as Activator, have an interest in the role of resonant frequencies in skeletal manipulation.[44-47]

One hypothesis is that the principles of resonant frequency may apply to the human spine. As a first step in this inquiry, the posteroanterior resonant frequency of the human spine was investigated. A posterior to anterior resonance in the range of 30 to 50 Hz (cycles per second) was found.[44] Other research of the human spine had previously established a resonance of 3 to 5 Hz in the inferior to superior dimension, which may be dampened by pelvic structures when they are in turn vibrated at 8 Hz.[42,43]

Theoretically, "a force of 150 N delivered at spinal resonance frequencies may accomplish the same work (vertebral displacement), as a nonresonant force delivered at 450 N at some other frequency."[46] Resonant frequency would explain why Herzog et al,[47] Maigne and Guillon,[48] and Cramer et al[49] found vertebral movements with hands-only adjusting to be virtually the same as the movement produced by Activator adjusting in terms of amount and direction of displacement. Evidence of the role of resonance in the transmission of force across fixated segments has yet to be established. Solinger[45,50] further explored the spine's resonant frequency by using a damped harmonic oscillator to simulate it. In his investigation, hands-only and AAI adjustments produced very similar oscillating frequencies, although hands-only adjustments produced higher amplitudes. Instrument and hands-only adjustments appeared equivalent in frequency content but differed in amplitude or quantity of force. Equivalency of the 2 in clinical outcomes is suggested in a few studies.[51,52]

In terms of skeletal response to adjustive forces, the AAI produced 1-mm relative translations, and 0.5° of rotation occurred in 19 milliseconds in an animal model.[26] In related study, piezoelectric accelerometers attached to the AAI established its usefulness as a noninvasive tool for measuring relative bone movement.[27] Bone movement by Activator was comparable to manual manipulation in later studies.[48,49] Gal et al[53] measured relative vertebral motions to spinal manipulative therapy on cadavers in the T10 to T12 area and found relative movements to approximately 1° of rotation and 1 mm in translation, displacements similar to earlier findings.[54]

Subsequent research using live human subjects established the first evidence of vertebral displacement in response to instrument adjusting. With Steinman pins inserted into the spinous processes of L4 and L5 to measure

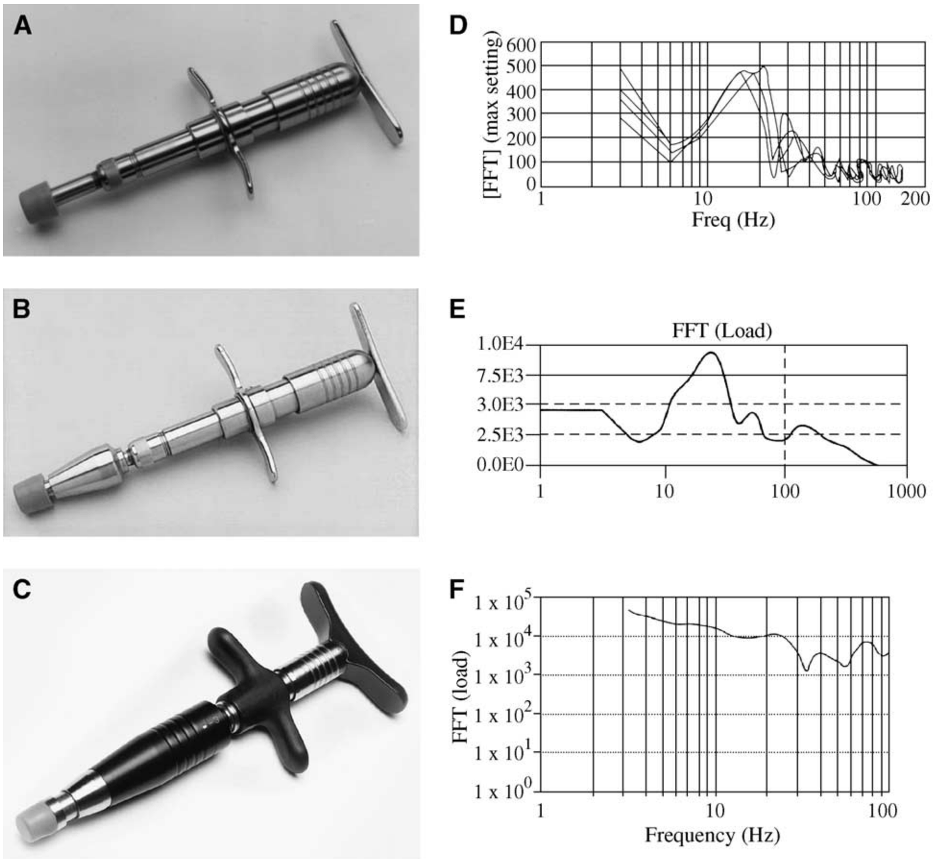

Fig 1. *Activator I-III (A-C) and corresponding force-frequency characteristics (D-F).*

vertebral movement, Activator thrusts were made on the spinous processes of T11 to L2, whereas recordings of vertebral motion were made at L4/L5. With peak forces of approximately 72 N, the L4 and L5 experienced axial displacement and posteroanterior shear displacement, while the L3 to L4 spinal segments were displaced in rotation.[44,55] Coupled motion was observed in vertebrae (L3 to L4), other than those receiving direct thrusts (T11 to T12).

Further investigation into the role of force in adjustment by Herzog et al[47] found total adjustive forces to be greater with manual as compared with Activator adjustments. But when measured on the target segment, forces were essentially the same for Activator and HVLA adjusting. Mechanical impedance, effective stiffness, and resonant frequency analysis were studied in reaction to AAI thrusts administered to 20 asymptomatic subjects.[44] Sex differences were noted, and higher impedance and stiffness were found in the lumbar versus thoracic regions. Findings again supported that the response to adjustment is determined in part by the approximation of the thrust to the resonant frequency of the spine. When others[56] artificially simulated the human spine in the laboratory, they found sagittal resonance frequency of 5.24 Hz produced axial displacement of 0.41 mm and rotations of up to 1.4°.

Further refinements in the force-frequency spectrum of the AAI included improving force delivery profiles as measured by Fast Fourier Transform analysis. In earlier models of the AAI, preadjustment pressures could reduce force frequencies by unintentionally compressing AAI springs. A frame was incorporated to stop inadvertent compression of the adjusting hammer spring during preloading. This "preload control frame" produced more reliable forces regardless of the initial contact pressures.[46,55] As a result, a new model of the AAI was developed (Activator III), which distributed approximately 1000 times more impulse energy across the resonant and potentially therapeutic mechanoreceptor frequencies of 2 to 100 Hz.[57] Fig 1 compares the models of the Activator I, II, and III in terms of force, frequency, and design characteristics.

In the resonant frequency range of 30 to 50 Hz, the lumbar spines of subjects were least stiff or exhibited the greatest mobility. There were also significant spinal region and sex differences. Spinal manipulative therapy impulses at a spinal resonant frequency will produce more spinal motion per given force, so long as muscle activity is kept to a minimum during the thrust. Muscle tension or recruitment has the effect of dampening or absorbing force input, reducing frequency content reaching mechanoreceptors.[58]

In Colloca and Keller's[59] study, the AAI was observed interacting with stiffness of low-back muscles in patients with and without chronic low-back pain (LBP). Activator thrusts on lumbosacral spinal landmarks produced measurable neuromuscular responses. Patients with chronic LBP had significantly greater stiffness in low-back musculature.

A few studies suggest that back pain may respond as effectively to the Activator as to hands-only adjusting,[51,60,61] perhaps by introducing vibrations or oscillations in spinal structures, similar to hands-only adjusting. The latter may result in joint cavitation: the audible "pop" sound produced with manipulation. It is not clear that cavitation is necessary for adjustment efficacy.[45,47,62]

In summary, various studies have investigated the effects of adjusting forces on the spine. Findings suggest that sagittal resonant frequencies of the spine range from 30 to 50 Hz. A theoretically important construct of relative movement from hands-only adjusting is similar to Activator adjusting, and the Activator III increases impulse energy in the 10- to 100-Hz frequency range, which has potential implications in spinal resonance and mechanoreceptor receptivity.

Biomechanics may play an important role in explaining the relationship of structure to function in the body. The theoretical distinctiveness of chiropractic has been attributed to a primary neurological mechanism assessed by radiographic, orthopedic, neurological, and palpatory indicators. In addition to a neurological mechanism, somatic function and stability could be based upon a proposed biophysical phenomenon named "tensegrity," which is a term coined by Buckminster Fuller referring to architectural tension plus compressive forces producing structural integrity and mechanical stability. Ingber[63] has extended the tensegrity concept to living systems. According to the tensegrity model, structures exist at many levels: from individual cells up to complex multisystem endoskeleton organisms. In cells, cytoskeletal microfilaments and portions of extracellular matrix bear tension, whereas cytoskeletal microtubules serve as compressive loading–bearing elements. Tensegrity contributes not only to cell shape but also to cell transduction, mechanical changes activating intracellular pathways affecting cell behavior.[63] In summary, selected cell functions are modified by its structure. At the macrolevel, muscles, ligaments, and joint capsules constitute tensile elements, and bones serve as compressive elements in the musculoskeletal system.[64] Analogous tensegrity principles may be at work in the vertebral column, contributing to structural relationship between spinal regions and to segmental stability and function.

The tensegrity model may offer an explanation of the spinal column's ability to remain vertically stable, that is, not buckling as a long column. Changes in load sharing between compressive elements because of small changes in vertebral position or between tensile elements are perhaps caused by contractures, adhesions, or changes in muscle tone. This, in turn, may have adverse segmental consequences biomechanically and subsequently physiologically.[65] Indeed, the tensegrity model may describe a mechanical infrastructure upon which clinical phenomena are observed using tests such as the isolation, pressure, and stress tests. This may be a fertile area of research for Activator Methods and the chiropractic profession as whole.

Neurophysiological dynamics. Neurophysiological research investigates the afferent and efferent responses to an adjustive force. In a sense, neurological research addresses hypotheses and theories fundamental to chiropractic. If a chiropractic adjustment is primarily a neurally mediated process, then elucidation of neurological responses to adjusting is necessary to the understanding of spinal manipulation. Vertebral displacement or disk compression may have effects beyond musculoskeletal pain and articular dysfunction, according to Bolton.[66] He referred to studies showing vertebral displacements modulating heart rate, blood pressure, and electrical activity in renal nerves, adrenal nerves, and gastrointestinal muscles.

Mechanoreceptors convert mechanical forces to neural impulses and are thus a topic of great interest to the chiropractic profession. Coactivation of mechanoreceptors is the result of neurons stimulated concurrently. Coactivated neurons include cutaneous receptors, muscle spindles, Golgi tendon organs, and joint capsule mechanoreceptors. Henderson[67] suggested that a burst of coactivated afferent input into the central nervous system normalizes muscle tone, joint mobility, and ancillary sympathetic activity. According to Herzog et al,[68] the complex heterogeneous neural responses to spinal manipulation could only result from coactivation, that is, the simultaneous firing of many types of receptors. If coactivation is indeed the intermediary mechanism of the adjustment, then how much force must be applied to accomplish this barrage of neural activity? Gillette[69] suggested that the typical adjustment was sufficient to produce a coactivation response, with its minimum of 40 N. Hands-only forces vary from 40 N for cervical adjusting to 400 N for lumbar adjusting.[70] The Activator is capable of producing coactivation because it introduces mechanical forces of 72 N for Activator II,[71] and up to 230 N for Activator III, but delivered in less time than manual adjusting[46,72]: 0.1 to 5 milliseconds for the former versus 30 to 150 milliseconds for the latter. Mixed nerve impulses produced in Activator adjusting research supported this capability (Table 3).[73]

Brodeur[62] noted that the audible sound during an adjustment (cavitation) does not necessarily indicate that appropriate reflexes have been stimulated. Herzog et al[74] subsequently showed that audible releases were irrelevant to evoking muscle activation or joint proprioceptive reflexes as measured by muscular responses of asymptomatic patients. His group found that speed of adjustment was more important than force[47,74] in producing neurological responses,[75,76] as measured in paraspinal musculature with electromyelograms.[74]

Table 3. *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	500-1200	1200-2600	200-900
External spinal manipulative thrusts	1200	800-3500	900

LOD, line of drive; *ant*, anterior; *sup*, superior; *inf*, inferior. Adapted with permission from *JMPT* 2000;23:453.[73]

In assessing Activator neural responses, Symons et al[77] inferred that they were likely generated by a single proprioceptor. In comparison to hands-only adjusting, Activator responses varied more among patients but were consistent within certain patients and more localized in effect, suggesting that spinal resonance was less of a factor in carrying the force distally to the adjustment. Overall, 68% of Activator-treated back muscles displayed a detectable neuromuscular response as measured by surface electromyelogram (sEMG).[77] The cervical spine responded to 50% of thrusts, thoracic spine 59%, lumbar spine 83%, and sacroiliac joints 94%. Others[72] have reported neuromuscular responses in 95% of 20 LBP patients treated by AAI adjustments, as measured in surface electromyography of lumbar paraspinal muscles. Another study of back-pain patients found significant temporary increases in trunk muscle strength after AAI lumbosacral adjustments.[78]

Fig 1 shows the range of frequencies generated from AAIs I, II, and III. Merkel disks and Meissner and Pacinian corpuscle mechanoreceptors would likely be stimulated by these AAI frequencies generated in a thrust.[79] The AAI III increases force magnitudes across the distribution of receptive frequencies, thus increasing the likelihood of a neurological coactivation response to the adjustment.

Mechanoreceptors display directional responsiveness to applied forces,[66,80-82] which are referred to as "receptive fields." Receptive fields may account for the suspected importance of the line of drive concept. One AAI study[73] suggested the importance of receptive fields in adjusting. An incision was made over the L3 to S2 midline in a 62-year-old volunteer patient, allowing direct AAI contact with vertebral bone. The S1 nerve root was monitored at the right dorsal root ganglion for mixed spinal nerve discharge. Next, AAI thrusts were made directly on the bone surface of the L5 mammillary process, to the overlying skin and paraspinal tissue, and at various angles or lines of drive (Fig 2). An anterior-superior and anterior-inferior line of drive increased mixed nerve responses by as much as 3 times over anteriorward-only vectors. Interestingly, external Activator impulses elicited higher average mixed nerve responses than those from direct thrusts on bone. Greater neural responses from external spinal manipulative thrusts suggested the role of nonosseous structures in manipulation (Table 3) or coactivation of joint, cutaneous, muscle and tendon receptors.

Fig 2. *Intraoperative Activator adjustment.*[73]

These findings suggest a preferential line of drive for adjustments through certain receptive fields,[82] maximizing neural discharge for any given force. Resonant frequencies may be a factor by conducting forces farther from the adjustive force to other proprioceptive receptors, mechanoreceptors, and cutaneous and muscle stretch receptors. By this reasoning, applying forces in a vector at resonant frequencies could maximize neural discharge. Caution is warranted because these findings involved a single patient.

Case studies. Thirteen descriptive case reports of patients receiving AAI adjustments are reported (Table 4). Positive outcomes with AAI adjusting have been reported for a variety of clinical problems, including acute LBP[83]; adhesive capsulitis[84,85]; Bell's palsy[86]; cervical disk protrusion with pain[87]; lumbar disk herniation with pain[88,89]; noncardiac (atypical) chest pain[90,91]; coccygodynia[92]; hypercholesterolemia[93]; otitis media[94]; plantar fasciitis[95]; postsurgical neck pain[96]; and torn knee ligament with joint restriction, swelling, and pain.[97] Henningham[98] noted positive outcomes with AMCT in cases of acute torticollis but offered no individual case data and is therefore not considered here.

Descriptive case studies do not permit conclusions about cause and effect to be drawn. Several of these reports involved multiple treatments (AAI plus other methods), which do not permit attributions of the effectiveness solely to AMCT. The selection bias of case reports, involving clinicians' greater likelihood of reporting successful outcomes, limits generalizability. As well, in this series of reports, the number of contributions from a single author should also be considered a potentially skewing factor. Additionally, most of these studies have relied upon

Table 4. *Characteristics of several case reports of positive experience for patients (n = 1-3) treated with the Activator Instrument*

Authors, date	Diagnosis	Subjects	Repeated observations	Treatments	Outcomes
Richards et al[89] (1990)	Disk herniation with sciatic neuropathy (n = 2)	1: 54-y-old man	1: CT scans, leg-length evaluations, orthopedic tests	1: AAI adjustments (39 TVs), pelvic blocking, high-voltage galvanic current, stretching, isometric and swimming exercises, food supplements	1: No disk herniation after 5 mo, pain relief not mentioned
		2: 36-y-old woman whose pain worsened with PT (traction)	2: CT scans, antalgia observations, orthopedic tests, muscle strength evaluations	2: AAI adjustments (49 TVs), "home exercises and swimming"	2: Returned to work after 5 mo, reduced and centralized disk herniation, reduced pain
Frach et al[86] (1992)	Bell's palsy with neck, TMJ pain, LBP, and facial paralysis (n = 2)	1: 18-y-old woman	Patients' self-report of symptoms; leg-length evaluations	1: AAI adjustments and "modified high-voltage therapy"	1: Improvement after 3 d, patient dismissed after 5 TVs, continued symptom-free at 14-mo follow-up
		2: 37-y-old man		2: AAI adjustments, high-voltage therapy, and "facial muscle exercises"	2: 60%-70% Symptom relief after 9 TVs; patient withdrew from care against advice
Peterson[93] (1995)	Hypercholesterolemia (n = 2)	1: 78-y-old woman	Pre/postadjustment monitoring of serum cholesterol levels	Single AAI adjustment during emotional arousal	1: 27.8% Reduction in serum cholesterol, short-term
		2: 60-y-old woman			2: 22.5% Reduction in serum cholesterol, short-term
Phillips[94] (1992)	Otitis media	2-y-old woman	Parental reports of symptoms and examination for exudate	Intermittent AAI adjusting of upper cervical spine in response to symptom recurrence	Initial improvement 3 d after first adjustment; relapse interrupted after subsequent adjustments; tubes expelled 2 y after first adjustment; symptom-free at 4-y follow-up
Polkinghorn[97] (1994)	Torn medial meniscus and knee pain	54-y-old woman	Informal self-report of pain, stiffness, and weakness; examinations for knee ROM, edema, and palpatory tenderness; MRI of knee	AAI adjustments to "collateral ligaments, tibia, fibula, patella and lumbopelvic mechanism," and homeopathic medicines ("Apis-Homaccord" and "Traumeel")	"Notable improvement" after 3 wk; further improvement after 7 wk; continued improvement at 15 wk; minimal change observed on MRI; symptom-free at 10 mo from onset of chiropractic care; surgery avoided
Polkinghorn[84] (1995)	Frozen shoulder (adhesive capsulitis) with severe pain and insomnia	53-y-old woman	Patients' self-report of symptoms; leg-length evaluations; shoulder ROM testing	AAI adjustments of shoulder and cervicothoracic spine; "G5" stimulation of trigger points; shoulder-stretching exercises	Sleep improved after sixth TV; gradual improvement over the next 4 wk; full recovery after 5 mo (35 TVs), discharged; symptom-free at 15 mo

Polkinghorn[95] (1995)	Plantar fasciitis with heel spurs (n = 3)	1: 59-y-old woman with 4-y history of pain	Isolation testing, self-report of pain and symptoms	AAI adjustments only	1: Gradual improvement, asymptomatic after first 2 mo (15 TVs), still symptom-free at 18-mo follow-up
		2: 55-y-old woman with 1-y history of pain and temporary relief from steroids			2: Asymptomatic after 1 mo (10 TVs), asymptomatic at 1-y follow-up
		3: 71-y-old woman with 2-mo history of pain			3: Immediate improvement at first treatment visit, asymptomatic after 4 wk (9 TVs), asymptomatic at 1-y follow-up
Polkinghorn[85] (1995)	Frozen shoulder	50-y-old woman with carcinoma of the breast and metastases to the humeral head, scapula, and clavicle	Isolation testing; self-report of symptoms; shoulder ROM testing	AAI adjustments only	"Immediate improvement" (pain relief and slightly better ROM after first adjustment; asymptomatic after 2 wk (7 TVs)
Polkinghorn[87] (1998)	Cervical disk protrusion with pain	42-y-old woman with pain aggravated by manual adjustments	Self-report of symptoms: pain	AAI adjustments, cervical support, hot pack, electrical stimulation, ROM exercises	"Favorable response" during wk 1 of treatment; "complete resolution of all symptoms" after 3.5 mo of treatment
Polkinghorn and Colloca[88] (1998)	L4-L5 disk herniation with LBP, sciatica, and foot drop	26-y-old man	Isolation testing; self-report of symptoms	AAI adjustments only	Improvement in all symptoms at 4 wk; pain-free at 90 d; still symptom-free at 1-y follow-up
Polkinghorn and Colloca[92] (1999)	Coccygodynia	29-y-old woman	Numerical pain ratings; pre/posttreatment isolation tests; self-report of symptoms	AAI adjustments, "primarily the sacrococcygeal ligament"	Relief of all pain within 24 h; pain-free at 3-mo follow-up
Polkinghorn and Colloca[96] (2001)	Postsurgical neck pain of 5-y duration	35-y-old woman postdiskectomy at C3-C4 and postfusion at C5-C6	Isolation testing; cervical ROM testing; self-report of pain	AAI adjustments only	Some pain relief after 1 wk (3 TVs); nearly pain-free after 1 mo; pain-free and near normal ROM after 2 mo; intermittent pain during the next 6 mo; discharged after 8 mo (30 TVs), avoided surgery
Polkinghorn[90] (2002); Polkinghorn and Colloca, 2003[84]	Noncardiac chest pain, dyspnea, and anxiety for more than 4 mo	49-y-old man with history of unsuccessful polypharmacy	Self-report of symptoms	AAI adjustments of thoracic spine and costosternal joints	Quick relief of symptoms after first adjustment; continued improvement over 14-wk treatment; improvement maintained at 9-mo follow-up

CT, Computed tomography; *PT*, physical therapy; *ROM*, range of motion; *TMJ*, temporomandibular joint; *TV*, treatment visit.

informal (nonquantitative) and unsystematic patient self-reports of symptoms as the primary clinical outcomes.

Nonetheless, these reports may provide the insight that could guide other clinicians faced with similar clinical problems, especially in instances involving unusual diagnoses or presentations. They are useful, therefore, in suggesting clinical possibilities rather than probabilities. Descriptive case reports, such as those noted here, may be used as springboards for more extensive investigations (eg, clinical series, controlled trials).

Clinical series. AMCT has been the subject of at least 3 clinical series (uncontrolled descriptive reports groups of patients). Gemmell and Jacobson[61] used the AAI adjustments as the sole intervention in 2 randomly assigned groups of LBP patients in whom adjustive targets were determined either by palpatory tenderness (n = 41) or by means of a Toftness instrument (n = 44). Both groups showed statistically significant pain reduction after a single AAI thrust, but there were no significant differences between groups. This short-term improvement is a common finding when either (1) both groups are equally effective or (2) neither is better than natural history. Because the Activator was a constant across groups, this study may be considered an uncontrolled series with respect to the effects of the intervention.

Osterbauer et al[99] monitored 10 neck-injured patients before and after 6 weeks of treatment by AMCT. Dependent variables included Visual Analogue Scale (VAS) pain ratings, cervical ranges of motion, and finite helical axis parameters, which are novel indicators of 3-dimensional head and neck motion implicated in soft-tissue injuries.[100,101] Clinically and statistically significant improvements were noted at the end of treatment and were generally maintained in the 7 patients who returned follow-up questionnaires 8 to 12 months later. Comparisons of patients' finite helical axis parameter findings with those of 9 asymptomatic volunteers supported the discriminative validity of this method of identifying altered motion.

Osterbauer et al[102] explored the usefulness of AMCT analysis and AAI adjusting in 10 patients with chronic sacroiliac joint syndrome. After 1-week pretreatment baseline monitoring of pain (VAS), disability (Oswestry Questionnaire), and several indices of gait and sway, patients underwent AAI adjusting during 3 weekly visits for 5 weeks. Comparisons of patients' baseline data with those collected at the end of treatment (all patients) and at 1-year follow-up (n = 6) revealed statistically and clinically significant short- and long-term reductions in pain and disability but no apparent effects on postural scores.

Recently, Coleman et al[103] investigated the effect of instrument adjusting upon cervical spinal curvature in a retrospective look of 13 post–motor vehicle accident patients adjusted with the Activator. Eleven of the 13 were instructed in mild stretching technique. Ten of 13 saw improvement in spinal curvature, including the patients not stretching. The average change in cervical curve among all patients during the course of the uncontrolled observation period was 6.4° (SE 2.3°; 95% confidence interval 1.4°-11.4°). A previous study was cited where change in spinal curvature could not be accomplished by stretching alone, nor was caused by the natural reduction of posttraumatic muscle splinting.[104] The relationship of spinal curve to symptomatic outcomes is unclear, but findings may suggest an advantage of instrument adjusting, because in another study,[105] manipulation alone was insufficient to bring about change in cervical curve.

In a cross-sectional descriptive study, 46% (44 of 96 chiropractors) of clinicians with older patients (age 55 or older) in a "practice-based research program"[106] were AMCT practitioners. A variety of demographic and descriptive information was collected on the chiropractors and their combined 805 patients, including practice characteristics; chief complaints; health habits; and several health, disability, and pain questionnaires. Because the data for Activator practitioners were not separated in the analysis, no outcome or preference comparisons with AMCT could be drawn.

Randomized clinical outcome trials. Studies in which treatment with the AAI (with or without AMCT analysis) was compared with other conditions (including placebo maneuvers and no treatment) and the potential effects on clinical outcomes were evaluated. Excluded from this review are reports wherein the AAI, set at 0 force, has been used exclusively as a placebo-control condition.[107-110]

In a "feasibility study for a clinical trial" of several chiropractic methods, Phongphua et al[111] compared AMCT to Gonstead and Bioenergetic Synchronization Technique in the treatment of migraine headaches. They noted that 5 of 22 patients evidenced improvement on the Headache Disability Index. Unfortunately, patients were not randomly assigned to treatment groups, and the authors did not report differential effects of the various treatment methods.

Yates et al[112] randomly assigned patients with "elevated blood pressure," defined as systolic >130 mm Hg and diastolic >90 mm Hg, to 3 conditions: treatment with the AAI (n = 7), a placebo control procedure with the adjusting device set in the "off position" (n = 7), and a no-treatment control group (n = 7). Dependent measures included blood pressures and scores on the State-Trait Anxiety Inventory, a paper-and-pencil indicator of apprehensiveness. Adjustment sites (apparently in the thoracic spine) were determined by unspecified palpatory procedures, and the adjustor was blinded to patients' scores for all dependent measurements. A single treatment was administered. Blood pressures decreased significantly in the active treatment group but not among placebo and no-treatment subjects. Curiously, state anxiety scores diminished significantly in active and no-treatment groups, but not among placebo-control patients. This could be attributed to factors other than the treatment.

Three studies have compared the effects of Activator adjusting to manually delivered thrusts. Gemmell and Jacobson[60] randomly assigned 30 acute LBP patients to either Meric (manual) adjusting (n = 16) or mechanical thrust with the Activator instrument (n = 14). The sites of intervention for both groups were determined by palpatory tenderness (leg-length analysis was not used), and the line of drive was "PA direction through the plane of the disk." A single experienced clinician administered both therapies. VAS pain ratings were made by each patient before and immediately after a single adjustment. Both groups reported reductions in pain approaching an average of 50%; there was no significant difference in outcome between them. However, without a control group, the clinical change could not be exclusively attributed to therapy.

Yurkiw and Mior[52] randomized 14 neck pain patients to either a Diversified (manual) adjustment (n = 7) or an AAI thrust (n = 7). Intervention was "restricted to the lower cervical spine" with the specific segmental level determined by motion palpation; leg-length analysis was not performed. Left and right lateral cervical flexion (measured by a blinded examiner using inclinometry) and VAS pain ratings were made before and after a single thrust. There were no significant differences between groups for either variable, but trends toward improvement were noted from pretesting to posttesting.

Wood et al[51] randomly assigned 30 patients with neck pain and restricted cervical motion to either a "standard Diversified rotary/lateral break technique" delivered in the supine position (n = 15) or AAI adjustments delivered in the prone position (n = 15). Sites of thrusting for both groups were determined by undescribed combinations of leg-length evaluations, "pain, localized tenderness, and the presence of a positive Kemp's test." Intervention was administered 2 or 3 times per week for up to 4 weeks or until "symptom-free." A maximum of 8 treatments were provided to any single patient. Subjective outcomes included the Neck Disability Index, Numerical Pain Rating Scale, and the McGill Short-form Pain Questionnaire; cervical ranges of motion in 6 directions were measured by inclinometry. These dependent measures were collected at the initial consultation, at the end of treatment, and at 1-month follow-up. A single clinician administered all measures and treatments. Both groups showed statistically significant improvements in range of motion and subjective parameters that persisted through 1-month follow-up, but there were no significant differences between the 2 methods of intervention.

Peterson[113] randomly assigned college students with simple phobias of small animals to AAI adjustment (n = 8) or placebo condition (with the AAI set to 0 force; n = 10). Before intervention, subjects' radial pulses were measured by a blinded registered nurse before and after exposure to the image of the phobic object, and they rated their anxiety on a VAS. Patients were also blinded to treatment assignment. Adjustments and placebo treatments were administered while the patients again contemplated the phobic stimulus. Sites for spinal thrusts were determined by manual muscle testing in association with acupuncture meridian points (as in Neuro-Emotional Technique protocol). Pulse and VAS ratings of anxiety were again recorded. No differences between groups were found for pulse; however, post-intervention ratings of anxiety were significantly lower in adjusted versus placebo-treated patients ($P < .05$) and from subjects' own preintervention ratings ($P < .001$). Patients may have experienced a state-anxiety reduction as a result of relief of treatment or anticipatory fear of spinal manipulation.

These 5 reports (Table 5), dealing with 4 clinical conditions and involving limited samples and limited intervention, do not permit strong conclusions about the relative merits of manual versus instrument-administered thrusts. However, because they provide the only available data bearing on the relative effectiveness of these 2 approaches, they should serve to temper a priori assumptions about the comparative usefulness of these differing modes of chiropractic treatment. Given the limitations noted, the possibility of type II errors (ie, falsely accepting the null hypothesis) must be kept in mind.

Consensus findings and expert ratings. Although the database for AMCT is limited, this treatment method is 1 of the better-studied techniques in chiropractic and may be 1 of the better-studied treatments for back disorders.[114] The AAI, a category of "mechanical force, manually assisted procedures," was determined to offer "promising to an established" evidence rating at the 1992 Mercy Center clinical guidelines consensus conference.[115] A consensus panel commissioned by the Canadian Chiropractic Association came to similar supportive conclusions for Activator adjusting.[116]

In a recent effort to evaluate the literature and rate interventions for various low-back conditions,[117,118] the paucity of evidence for many treatment/condition combinations was noted. The ratings of the clinical experts used by these investigators yielded relatively low scores for instrument adjusting. Although the authors advise that "comparison of procedure ratings must be made with caution," their findings underscore the need for a great deal more outcomes research for AMCT and various other chiropractic methods of health care.

We believe that the project of Gatterman et al has been misinterpreted in several respects. One misunderstanding has been that the differential ratings for techniques indicate a rank ordering of effectiveness.[119] Another misinterpretation has been that this rating project was equivalent to scientific evidence, rather it being correctly recognized as a summary of opinions made by clinicians who had reviewed available literature and combined these insights with personal experience. In a follow-up letter to the editor, Gatterman[120] notes the preliminary character of this effort to evaluate the evidence for specific treatment protocols for specific conditions. She calls for greater skill in the interpretation of research papers and reiterates the call for greatly increased clinical outcome studies in chiropractic. Gleberzon[37] repeats Gatterman's reminder that "a paucity of evidence one way or another does not constitute evidence of ineffectiveness."

Table 5. *Characteristics of several randomized group trials with the activator instrument*

Authors, date	Diagnosis	Design	Repeated observations	Outcomes
Yates et al[112] (1988)	Elevated blood pressure	3 Randomized groups: single AAI adjustment (n = 7), placebo adjusting (n = 7), and no-treatment control (n = 7)	Systolic and diastolic blood pressures, STAI	Significant reductions in blood pressures among subjects who received AAI adjustments but not among placebo and no-treatment subjects; significant reduction in STAI scores among AAI adjusted and no-treatment subjects, but not in placebo controls
Gemmell and Jacobson[60] (1995)	Acute low-back pain	2 Randomized groups: single Meric (manual) adjusting (n = 16) or single AAI adjustments (n = 14)	VAS pain ratings	Mean pain reductions of 50% in both groups, but no significant differences between groups
Yurkiw and Mior[52] (1996)	Neck pain	2 Randomized groups: single diversified (manual) adjustment (n = 7) or single AAI adjustment (n = 7)	Inclinometric measurements of right and left lateral flexion and VAS pain ratings	Nonsignificant improvements in both groups, but no significant differences between groups
Peterson[93] (1995)	Simple phobias	2 Randomized groups: single AAI adjustment during emotion arousal (n = 8) or single placebo adjustment during emotional arousal (n = 10)	Radial pulses and VAS anxiety ratings	No significant changes in pulse observed, but anxiety was significantly reduced in treated versus control patients
Wood et al[51] (2001)	Neck pain and restricted cervical motion	2 Randomized groups treated 2-3 times weekly for up to 4 wk or maximum of 8 treatments: diversified rotary/lateral break adjustment (n = 15) or AAI adjustments (n = 15)	Neck Disability Index, Numerical Pain Rating Scale 101, McGill Short-form Pain Questionnaire, 6 cervical ROMs	Statistically significant improvements in subjective measures and ROMs relative to baseline in both groups at end of treatment and 1-mo follow-up; no significant differences between groups

STAI, State-Trait Anxiety Inventory.

Use, Training, and Certification

AMCT is taught in the majority of US chiropractic colleges and is offered at several schools internationally. An estimated 45,000 doctors of chiropractic throughout the world now use some or all of this technique, and surveys of chiropractors by the National Board of Chiropractic Examiners report that "Activator" is used by more than half of the profession, who use these procedures in slightly more than one fifth of their case loads.[121] In the United States, the percentage of practitioners using AMCT increased from 51.2% in 1991 to 62.8% in 1998. In Europe, it was estimated that the technique was used in 14% of chiropractic cases in 1994.[122] The AMCT is also widely used in Canada[37,123,124] and Australia. An estimated 75,000 AAIs have been sold since 1967.

Clinical practice guidelines from the Mercy conference rated AMCT "promising to established"[115]; ratings from the Glenerin conference suggested that AMCT was "promising for neuromusculoskeletal disorders."[116] AMCT is taught as 1 component of many chiropractors' broader skills and should be integrated with the competencies and knowledge acquired in doctoral training and subsequent clinical experience.

Instruction in AMCT takes place in a variety of settings. A number of chiropractic colleges offer training in AMCT in their doctoral and postdoctoral (relicensure) seminars, and student "Activator Clubs" can be found on many college campuses (Table 6). At those schools which do not offer formal training in AMCT, discussion of these methods is sometimes provided through guest lectures and courses which survey "brand name" techniques (eg, Southern California University of Health Sciences). Student interest in AMCT is high.[37,123] One study[125] found that chiropractic students taught AMCT in college tended to use the technique in their subsequent practices.

Seminars (with and without relicensure credit) are offered by AMI, Ltd, throughout North America (Canada, Mexico, and United States) and overseas (Australia, Britain, France, Japan, Mexico, New Zealand, and Taiwan). Seminar instructional methods include lecture, small group activities, and feedback to participants on their performance. All instructors (seminar- and college-based) are expected to achieve "advanced proficiency rated" standing through recertification each year with AMI, Ltd. A clinical advisory board oversees all curriculum development and sets standards for competency testing.

Training materials include videotapes, CD-ROM presentations, handouts, the Activator Web site (www.activator.com), and the textbook *Activator Methods Chiropractic Technique*.[1] Seminar instruction in AMCT involves 3 sequential tracks. Track 1 involves training in the basics

Table 6. *Instruction in activator methods chiropractic technique at chiropractic colleges*

College	Required in doctoral program	Elective in doctoral program	Postdoctoral (relicensure) offering	Activator club*
Canadian Memorial Chiropractic College				X
Cleveland Chiropractic College of Kansas City		X	X	X
Cleveland Chiropractic College of Los Angeles		X	X	
Life University, Georgia		X	X	X
Life Chiropractic College West		X	X	
Logan College of Chiropractic		X	X	X
New York Chiropractic College		X		X
Palmer College of Chiropractic		X	X	
Palmer College of Chiropractic West		X		X
Parker College of Chiropractic	X			
Sherman College of Straight Chiropractic				X
Northwestern University of Health Sciences		X		
Texas College of Chiropractic	X			
Université de Québec àTrois Rivières		X		
Anglo European College of Chiropractic, England		X		
Macquarie University, Sidney, Australia		X		
Universidad Estatae Del Valle de Ecatepec, Mexico City	X			

* Activator Clubs active as of Spring 2002 term.

of prone leg checks, isolation testing (pelvis to occiput), and adjusting procedures. Track 2 builds upon earlier instruction, including a review of leg-length evaluations, isolation maneuvers, and instrumental procedures, including those for extremities. Track 3 involves tutoring in case management treatment algorithms, outcome assessments, and review of credentialing for managed care requirements. An examination leading to certification as "proficiency-rated" in AMCT is administered after track 1; "advanced proficiency-rated" certification is available by examination to those who have completed track 2.

Conclusion

After 35 years of development and research, AMCT has become 1 of the many techniques from which doctors of chiropractic draw their clinical procedures, and the AAI is a common component of the chiropractor's armamentarium. Scholarly attention has been directed to some of the measurement characteristics of AMCT analysis, from the physics of the instrument to the AAI's biomechanical and neurophysiological effects, and outcomes generated by the technique. The diversity of technique questions that need be addressed calls for a variety of research designs for studying health care technology. Case studies, for example, may be useful in illustrating clinical possibilities and, in some iterations (eg, single-subject experimentation), may offer strong internal validity.[126] Randomized clinical trials are more expensive and time consuming but may provide a greater degree of internal and external validity. Reliability studies provide screening research preliminary to more involved investigations of validity. Each makes a contribution to resolving the uncertainties of clinical practice.

Research related to AMCT has involved many types of systematic inquiries. A summary of the AMCT-relevant studies related to basic science and safety and clinical outcomes, based on the work of Taylor et al,[127] is offered in Table 7, according to the type of question addressed and the quality of evidence. The Taylor classification was based on the Glenerin Clinical Guidelines for Chiropractic Practice in Canada.[127] Class 1 evidence involves experimental studies with control comparisons and addresses efficacy and safety. Class 2 evidence is comprised of observational studies of groups, which lack control groups, such as case-control and cohort designs. Class 3 evidence includes descriptive studies, case reports, and expert opinion. Besides revealing areas of accomplishment, Table 7 also points to gaps and weaknesses in the knowledge base for AMCT assessment and intervention. These may be directions for future investigation.

Although treatment by AMCT has been investigated from case reports to randomized controlled trials (RCTs), many questions about AMCT remain unanswered. One shortcoming is the insufficiency of RCTs to substantiate (or refute) the clinical utility (efficacy, effectiveness) of AMCT interventions. However, this weakness needs to be understood within the context of the limited validation efforts for all chiropractic methods. To the best of our knowledge, side-posture lumbar manipulation for LBP patients is unique among manipulative procedures for the volume[118,128] of RCTs currently available to support its usefulness in acute and chronic conditions of the low back.

The success that side-posture lumbar manipulation has enjoyed in RCTs of patients with LBP has prompted suggestions that all other chiropractic methods of helping patients should be abandoned unless and until they are validated.[119] We believe that this perspective constitutes a

Table 7. *Studies of mechanical adjusting devices classified by areas of inquiry and quality of evidence (based on Taylor et al, 2002[127])*

	Basic science research	Clinical science research	
Evidence quality	Biomechanical, neurophysiological	Safety	Efficacy, effectiveness, comparison to other chiropractic techniques
Class 1	Colloca and Keller[72] (2001a), Herzog et al[135] (1993), Keller and Colloca[78] (2000)	Gemmell and Jacobson[61] (1998), Keller and Colloca[78] (2000), Wood et al[51] (2001), Yates et al[112] (1988)	Gemmell and Jacobson[60] (1995), Keller and Colloca[78] (2000), Wood et al[51] (2001), Yurkiw and Mior[52] (1996), Yates et al[112] (1988)
Class 2	Herzog et al[135] (1993), Kawchuk and Herzog[30] (1993), Symons et al[77] (2000), Solinger[50] (2000)	Kawchuk and Herzog[30] (1993), Solinger[50] (2000)	Hawk et al[108] (1999), Osterbauer et al[99] (1992)
Class 3	Osterbauer et al[102] (1993)	Cooperstein[3] (1997), Nykoliation and Mierau[36] (1999), Philips[94] (1992), Polkinghorn[85] (1995), Polkinghorn and Colloca[88] (1998), Polkinghorn and Colloca[96] (2001), Richards et al[89] (1990), Triano[136] (2001), Triano[137] (2002)	Frach et al[86] (1992), Phillips[94] (1992), Polkinghorn[97] (1994), Polkinghorn[85] (1995), Polkinghorn[95] (1995), Polkinghorn[85] (1995), Polkinghorn and Colloca[88] (1998), Polkinghorn and Colloca[92] (1999), Richards[89] (1990)

Not all AMCT studies are included in this schema, and some studies fall into more than 1 classification. Categories of research questions appear along the horizontal axis and a hierarchy of classes of evidence along the vertical axis.

misunderstanding of evidence-based practice, in that it suggests that only experimentally established procedures should be used by doctors. We concur that side-posture lumbar manipulation will often be a reasonable choice for assisting LBP patients; however, clinical experience suggests that not all patients tolerate this particular method. Doctors of chiropractic and other practitioners of the manual arts have multiple treatment strategies and will always be expected to tailor their interventions to meet the needs of individual patients.[129] The procedures comprising AMCT constitute potentially useful additions to the clinician's armamentarium, and preliminary comparisons of AMCT with manual adjusting for LBP[60] and for neck pain[51,52] suggest an equivalence of outcomes.

The AMCT method of analysis shows the same inadequacies that are endemic to the field of manual therapies. Although the leg-length checks involved in AMCT analysis, position 1, seem to be reliable, other factors need to be studied (concurrent validity, predictive validity, reliability, responsiveness, sensitivity, specificity, negative and positive likelihood ratios, predictive values, and relative utility of the larger assessment methodology). The choice of intervention sites for various painful and dysfunctional conditions of the musculoskeletal system is still a part of the "art" of chiropractic health care. The validity of subluxation syndrome has not been experimentally established.[130] To this end, we believe, efforts to monitor spinal dysfunctions within RCTs, by AMCT methods and the other analytic procedures, will be necessary to determine whether these suspected "lesions" are worthy targets and predictors of response to adjusting. Concurrently monitored subluxation indicators and clinical outcomes will permit evaluation of the "trial validity"[126,130] of the indicators and of their contribution of the assessment to clinical outcomes.[131]

The AAI may offer an advantage over manual adjustments for research studies of physical and physiological responses to thrusts: the speed and force of the impulse are known (controlled), whereas manual thrusts are variable. This greater control is not necessarily a source of better clinical outcomes but has stimulated a variety of basic science investigations within and beyond the profession. These have explored the instrument's mechanical output, biomechanical responsiveness, and patterns of neurophysiological stimulation. This research has involved bench science, animal models and human, in vivo studies and has given a theoretical picture of the AAI's contribution to spinal manipulation by spinal resonance and mechanoreceptor stimulation (or coactivation).

Health services research is an important area of inquiry for health care systems. According to the Institute of Medicine,[132] health services research involves both basic and clinical studies to examine "use, costs, quality, accessibility, delivery, organization, financing, and outcomes of health care services." Some of the cost-effectiveness of chiropractic services studies have been equivocal to disappointing.[133,134] This represents a challenge to the profession: to show its value as an integrated component of the health care delivery system. Thus, health services research should become an additional area of inquiry for the future of AMCT and the profession.

A body of basic science and clinical research has been generated on the AAI since its first peer-reviewed publication more than 35 years ago. The Activator analysis may be a clinically useful tool, but its ultimate scientific validation requires testing using sophisticated research models in the areas of neurophysiology, biomechanics, and statistical analysis. This review has provided a summary of the current research available and has recommended courses for future research for AMCT.

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