	Research Studies Examining the Clinical Relevance, Predictive Validity and Accuracy of MMT
Can the Ileocecal Valve Point Predict Low Back Pain Using Manual Muscle Testing? Pollard HP, Bablis P, Bonello R.	*Chiropr Aust* 2006;36:58-62 **Background:** According to some technique groups in chiropractic the ileocecal valve may malfunction and be associated with a large array of health problems that can lead to common chronic health issues prevalent in our society. Many tests commonly used in chiropractic are presumed to identify painful and/or dysfunctional anatomical structures, yet many have undemonstrated reliability. Despite this lack of evidence, they form the basis of many clinical decisions. One cornerstone procedure that is frequently used by chiropractors involves the use of manual muscle testing for diagnostic purposes not considered orthopaedic in nature. A point of the body referred to as the ileocecal valve point is said to indicate the presence of low back pain. This procedure is widely used in Applied Kinesiology (AK) and Neuro-Emotional Technique (NET) chiropractic practice. **Objective:** To determine if correlation of tenderness of the "ileocecal valve point" can predict low back pain in sufferers with and without low back pain. It was the further aim to determine the sensitivity and specificity of the procedure. **Methods:** One hundred (100) subjects with and without low back pain were recruited. Subjects first completed information about their pain status, then the practitioner performed the muscle testing procedure in a separate room. The practitioner provided either a *yes* or *no* response to a research assistant as to whether he had determined if the subject had back pain based on the muscle test procedure. **Results:** Of 67 subjects who reported low back pain, 58 (86.6%) reported a positive test of both low back pain and ICV point test. Of 33 subjects, 32 (97%) with no back pain positively reported no response to ICV point test. Nine (9) subjects (13.4%) reported false negative ICV tests and low back pain, and 1 subject (3%) reported a false positive response for ICV test and no low back pain. **Conclusion:** The majority of subjects with low back pain reported positive ileocecal valve testing, and all but one of the subjects without low back pain reported negative ileocecal valve testing. The application of ileocecal valve testing as a diagnostic measure of low back pain was found to have excellent measures of sensitivity, specificity and diagnostic competency. This study confirms that the use of this test within the limitations of this study is reliably associated with the presence of low back pain. Further testing is required to investigate all aspects of the diagnostic milieu commonly used by proponents of this form of diagnostic testing. **Comment:** In AK, the ileocecal valve dysfunction is not related automatically to low back pain though this is a frequent consequence of the problem. Another interesting research question that might have been posed to the subjects of this study would have been whether they had experiencing any digestive difficulties and its relationship to positive MMT outcomes. The finding of excellent sensitivity and specificity in this research report is noteworthy.
A hypothesis of chronic back pain: ligament subfailure injuries lead to muscle control dysfunction, Panjabi M.	*Eur Spine J.* 2005 Jul 27 **Abstract:** Clinical reports and research studies have documented the behavior of chronic low back and neck pain patients. A few hypotheses have attempted to explain these varied clinical and research findings. A new hypothesis, based upon the concept that subfailure injuries of ligaments (spinal ligaments, disc annulus and facet capsules) may cause chronic back pain due to muscle control dysfunction, is presented. The hypothesis has the following sequential steps. Single trauma or cumulative microtrauma causes subfailure injuries of the ligaments and embedded mechanoreceptors. The injured mechanoreceptors generate corrupted transducer signals, which lead to corrupted muscle response pattern produced by the neuromuscular control unit. Muscle coordination and individual muscle force characteristics, i.e. onset, magnitude, and shut-off, are disrupted. This results in abnormal

	stresses and strains in the ligaments, mechanoreceptors and muscles, and excessive loading of the facet joints. Due to inherently poor healing of spinal ligaments, accelerated degeneration of disc and facet joints may occur. The abnormal conditions may persist, and, over time, may lead to chronic back pain via inflammation of neural tissues. The hypothesis explains many of the clinical observations and research findings about the back pain patients. The hypothesis may help in a better understanding of chronic low back and neck pain patients, and in improved clinical management. **Comment:** This is one of the most important articles published to date on the musculoskeletal aspects of the subluxation. Dr. Panjabi is the world's most published human biomechanical researcher, with 263 published articles to date. The hypothesis he presents in this paper places the functionality of muscles, as both a cause and a consequence of mechanoreceptor dysfunction in chronic back pain patients, at the center of a sequence of events that ultimately results in back pain. As a result of spinal subluxations, muscle coordination and individual muscle force characteristics, i.e. inhibited muscles on MMT, are disrupted. The injured mechanoreceptors generate corrupted transducer signals (that could be detected by EMG, dynamometers, or MMT), which lead to corrupted muscle response patterns produced by the neuromuscular control unit. This article is very important for those in the chiropractic profession who are evaluating the existence and the consequences of the subluxation. The key technical factor that makes AK indispensable in the detection of spinal dysfunction is the MMT that makes the detection of muscular imbalance verifiable.
Scapular muscle tests in subjects with shoulder pain and functional loss: reliability and construct validity, Michener LA, Boardman ND, Pidcoe PE, Frith AM.	*Phys Ther.* 2005 Nov;85(11):1128-38. **BACKGROUND AND PURPOSE:** Scapular muscle performance evaluated with a handheld dynamometer (HHD) has been investigated only in people without shoulder dysfunction for test-retest reliability of data obtained with a single scapular muscle test. The purpose of this study was to assess the reliability, error, and validity of data obtained with an HHD for 4 scapular muscle tests in subjects with shoulder pain and functional loss. **SUBJECTS AND METHODS:** Subjects (N=40) with shoulder pain and functional loss were tested by measuring the kilograms applied with an HHD during 3 trials for muscle tests for the lower trapezius, upper trapezius, middle trapezius, and serratus anterior muscles. Concurrently, surface electromyography (sEMG) data were collected for the 4 muscles. The same procedures were performed 24 to 72 hours after the initial testing by the same tester. Muscle tests were performed 3 times, and the results were averaged for data analysis. **RESULTS: Intraclass correlation coefficients for intratester reliability of measurements of isometric force obtained using an HHD ranged from .89 to .96.** The standard error of the measure (90% confidence interval [CI]) ranged from 1.3 to 2.7 kg; the minimal detectable change (90% CI) ranged from 1.8 to 3.6 kg. Construct validity assessment, done by comparing the amounts of isometric muscle activity (sEMG) for each muscle across the 4 muscle tests, revealed that the muscle activity of the upper trapezius and lower trapezius muscles was highest during their respective tests. Conversely, the isometric muscle activity of the middle trapezius and serratus anterior muscles was not highest during their respective tests. **DISCUSSION AND CONCLUSION:** In people with shoulder pain and functional loss, the intrarater reliability and error over 1 to 3 days were established using an HHD for measurement of isometric force for the assessment of scapular muscle performance. Error values can be used to make decisions regarding individual patients. Construct validity was established for the lower and upper trapezius muscle tests; therefore, these tests are advocated for use. However, construct validity was not demonstrated for the serratus anterior and middle trapezius muscle tests as performed in this study. Further investigation of these muscle tests is warranted. **Comment:** The correlation between MMT and HHD findings has been established in much of the research literature. This paper shows that there is a construct validity and reliability to employing MMT and HHD testing in patients with shoulder injuries.
A comparison of muscle strength	*Neurology.* 2003 Dec 9;61(11):1503-7.

testing techniques in amyotrophic lateral sclerosis, Great Lakes ALS Study Group.	**OBJECTIVE: To assess the reliability of strength testing techniques among centers investigating patients with amyotrophic lateral sclerosis. METHODS:** The authors compared test reliability in manual muscle testing (MMT) and maximal voluntary isometric contraction (MVIC) scores among institutions and test validity by comparing change over time between MMT and MVIC. The authors examined 63 subjects at 3-month intervals for 12 months. At enrollment and at 6 months, two physical therapists each examined the subjects twice. MMT scores were calculated as modifications of the Medical Research Council scale. MVIC scores were generated as standardized megascores. Intraclass correlation coefficients and coefficients of variation compared reproducibility, and Pearson correlation coefficients compared change over time. The power of each measure to detect disease progression over time was assessed by estimating coefficients of variation for the average change. **RESULTS: Reproducibility between MVIC and MMT was equivalent. Sensitivity to detect progressive weakness and power to detect this change, however, favored MMT, an effect largely accounted for by the number of muscles sampled. CONCLUSIONS:** In multicentered trials**, uniformly trained physical therapists reproducibly and accurately measure strength by both MMT and MVIC. The authors found MMT to be the preferred measure of global strength because of its better Pearson correlation coefficients, essentially equivalent reproducibility, and more favorable coefficient of variation.** **Comment:** This paper is very important in understanding the clinical value (validity) of MMT in patients with neurologic disorders. It demonstrates that MMT is a more sensitive, more reliable and valid measure of dysfunction in patients with ALS than MVIC, which is another common method of muscle function evaluation.
Comparison of four tests of quadriceps strength in L3 or L4 radiculopathies, Rainville J, Jouve C, Finno M, Limke J. -- The Spine Center, New England Baptist Hospital, Boston, MA 02120, USA. jrainvil@caregroup.harvard.edu	*Spine.* 2003 Nov 1;28(21):2466-71 **STUDY DESIGN:** This prospective cohort study evaluated four office tests of quadriceps strength in symptomatic adults with radiographic evidence of L3 or L4 nerve root compression. **OBJECTIVE:** The study observed the performance of each test for its ability to detect quadriceps weakness when compared to the asymptomatic side. To determine the potential influence of radicular pain on the performance of the four tests, a control group of patients over the age of 40 with clinical and radiographic L5 or S1 radiculopathies underwent identical testing of quadriceps strength. **SUMMARY OF BACKGROUND DATA:** The L3 and L4 nerve roots innervate the quadriceps; therefore, quadriceps weakness may be a consequence of L3 or L4 radiculopathies. There are no standardized or validated methods to evaluate quadriceps strength in the clinical office setting. This may lead to inconsistent detection by clinicians of quadriceps weakness in cases of L3 or L4 radiculopathy. **METHODS:** Thirty-three consecutive patients with L3 or L4 radiculopathies and 19 with L5 or S1 radiculopathies were studied. The four tests of quadriceps strength included: 1) single leg sit-to-stand test; 2) step-up test; 3) knee-flexed manual muscle testing; and 4) knee-extended manual muscle testing. Results from a second examiner repeating the four tests were used to calculate interrater reliability. **RESULTS:** In L3 and L4 radiculopathies, unilateral quadriceps weakness was detected by the single leg sit-to-stand test in 61%, by knee-flexed manual muscle testing in 42%, by step-up test in 27% and by knee-extended manual muscle testing in 9% of patients. The sit-to-stand test detected weakness in all but one case when weakness was detected by another test. All patients with L5 or S1 radiculopathies could perform the sit-to-stand test. Kappa coefficient was high for sit-to-stand test (0.85), step-up (0.83), and knee-flexed manual muscle testing (0.66), and low for knee-extended manual muscle testing (0.08). **CONCLUSION:** In L3 and L4 radiculopathies, unilateral quadriceps weakness was best detected by a single leg sit-to-stand test. Patients of similar age with radicular pain caused by L5 or S1 radiculopathies could perform this test. As the interrater reliability of the single leg sit-to-stand test is high, clinicians should consider utilizing this test for assessing quadriceps strength in cases of L3 and L4 radiculopathies.

Evidence of Altered Lumbopelvic Muscle Recruitment in the Presence of Sacroiliac Joint Pain, Hungerford B, Gilleard W, Hodges P	*Spine* 2003; 28(14):1593-1600 **Study Design.** Cross-sectional study of electromyographic onsets of trunk and hip muscles in subjects with a clinical diagnosis of sacroiliac joint pain and matched control subjects. **Objectives**. To determine whether muscle activation of the supporting leg was different between control subjects and subjects with sacroiliac joint pain during hip flexion in standing. **Background**. Activation of the trunk and gluteal muscles stabilize the pelvis for load transference; however, the temporal pattern of muscle activation and the effect of pelvic pain on temporal parameters has not been investigated. **Methods**. Fourteen men with a clinical diagnosis of sacroiliac joint pain and healthy age-matched control subjects were studied. Surface electromyographic activity was recorded from seven trunk and hip muscles of the supporting leg during hip flexion in standing. Onset of muscle activity relative to initiation of the task was compared between groups and between limbs. **Results**. The onset of obliquus internus abdominis (OI) and multifidus occurred before initiation of weight transfer in the control subjects. The onset of obliquus internus abdominis, multifidus, and gluteus maximus was delayed on the symptomatic side in subjects with sacroiliac joint pain compared with control subjects, and the onset of biceps femoris electromyographic activity was earlier. In addition, electromyographic onsets were different between the symptomatic and asymptomatic sides in subjects with sacroiliac joint pain. **Conclusions**. The delayed onset of obliquus internus abdominis, multifidus, and gluteus maximus electromyographic activity of the supporting leg during hip flexion, in subjects with sacroiliac joint pain, suggests an alteration in the strategy for lumbopelvic stabilization that may disrupt load transference through the pelvis.
Neck muscle fatigue affects postural control in man, Schieppati M, Nardone A, and Schmid M.	*Neuroscience,* 2003;121(2):277-285. **Abstract:** We hypothesized that, since anomalous neck proprioceptive input can produce perturbing effects on posture, neck muscle fatigue could alter body balance control through a mechanism connected to fatigue-induced afferent inflow. Eighteen normal subjects underwent fatiguing contractions of head extensor muscles. Sway during quiet stance was recorded by a dynamometric platform, both prior to and after fatigue and recovery, with eyes open and eyes closed. After each trial, subjects were asked to rate their postural control. Fatigue was induced by having subjects stand upright and exert a force corresponding to about 35% of maximal voluntary effort against a device exerting a head-flexor torque. The first fatiguing period lasted 5 min (F1). After a 5-min recovery period (R1), a second period of fatiguing contraction (F2) and a second period of recovery (R2) followed. Surface EMG activity from dorsal neck muscles was recorded during the contractions and quiet stance trials. EMG median frequency progressively decreased and EMG amplitude progressively increased during fatiguing contractions, demonstrating that muscle fatigue occurred. After F1, subjects swayed to a larger extent compared with control conditions, recovering after R1. Similar findings were obtained after F2 and after R2. Although such behavior was detectable under both visual conditions, the effects of fatigue reached significance only without vision. Subjective scores of postural control diminished when sway increased, but diminished more, for equal body sway, after fatigue and recovery. Contractions of the same duration, but not inducing EMG signs of fatigue, had much less influence on body sway or subjective scoring. We argue that neck muscle fatigue affects mechanisms of postural control by producing abnormal sensory input to the CNS and a lasting sense of instability. Vision is able to overcome the disturbing effects connected with neck muscle fatigue.
Do cerebral potentials to magnetic stimulation of paraspinal muscles reflect changes in palpable muscle spasm, low back pain, and activity	*J Manipulative Physiol Ther.* 2002 Jan;25(1):77-8. OBJECTIVE: Previous studies have shown that cortical-evoked potentials on magnetic stimulation of muscles are influenced by muscle contraction, vibration, and muscle spasm. This study was carried out to determine whether these potentials correlate with palpatory

scores? Zhu Y, Haldeman S, Hsieh CY, Wu P, Starr A.	muscle spasm, patient symptoms, and disability in patients with low back pain. METHODS: A prospective observational study was performed on 13 subjects with a history of low back pain visiting an orthopedic hospital-based clinic. Patients were screened for serious pathologic conditions by an orthopedic surgeon. The patients were then evaluated for the presence of muscle spasm by one of the investigators who was blinded to the results of the evoked potential studies. Patients were asked to complete a low back pain visual analogue scale (VAS) and a Roland-Morris Activity Scale (RMAS). Cortical-evoked potentials were recorded with a magnetic stimulator placed over the lumbar paraspinal muscles with the patient in the prone position. The palpatory examination, VAS, RMAS, and the cortical potentials were repeated after 2 weeks of therapy commonly used to reduce muscle spasm. RESULTS: The patients demonstrated a significant decrease in low back pain VAS and RMAS scores after treatment compared with before treatment. There was a reduction in the amount of palpatory muscle spasm in 11 of 13 cases. The cortical potentials before treatment were attenuated compared with previously reported controls and showed a significant increase before and after treatment in the amplitude of these potentials with multivariate analysis of variance. There was significant correlation between the changes in cortical potentials after treatment and the changes noted in paraspinal muscle spasm and VAS and RMAS scores. CONCLUSIONS: This study confirms the previous report that the amplitude of cerebral-evoked potentials on magnetic stimulation of paraspinal muscles is depressed in the presence of palpable muscle spasm. **The close correlation among these potentials, paraspinal muscle spasm, and clinical symptoms suggests that the measurement of muscle activity may be more important in the assessment of low back pain than is commonly accepted.** **Comment:** This hypothesis has been made in AK since the technique was founded. Through evaluation of the function of certain muscles pre- and post-treatment, therapeutic efficacy for particular problems can be evaluated. Applied kinesiologists theorize that physical, chemical, and mental imbalances are associated with secondary muscle dysfunction – specifically a muscle inhibition (usually preceding an overfacilitation of an opposing muscle). Applying the proper therapy results in improvement in the inhibited muscle. This study demonstrates the simultaneous presence of muscle spasm and depressed cortical-evoked potentials in patients with low back pain. After 2 weeks of chiropractic spinal therapy the patients were alleviated of their clinical symptoms and increased the synaptic efficacy of Ia afferent activation to the central nervous system.
Sensorimotor control of the spine, Holm, S., Indahl, A., Solomonow, M.	*Journal of Electromyography and Kinesiology*, 2002, 12;3:219-234. (http://www.isek-online.org/) **Abstract:** The spinal viscoelastic structures including disk, capsule and ligaments were reviewed with special focus on their sensory motor functions. Afferent capable of monitoring proprioceptive and kinesthetic information are abundant in the disc, capsule and ligament. Electrical stimulation of the lumbar afferents in the discs, capsules and ligaments seem to elicit reflex contraction of the multifidus and also longissimus muscles. The muscular excitation is pronounced in the level of excitation and with weaker radiation 1 to 2 levels above and below. Similarly, mechanical stimulation of the spinal viscoelastic tissues excites the muscles with higher excitation intensity when more than one tissue (ligaments and discs for example) is stimulated. Overall, it seems that spinal structures are well suited to monitor sensory information as well as to control spinal muscles and probably also provide kinesthetic perception to the sensory cortex. **Comment:** The new and strikingly original feature of AK is that it brings together in a functional, inseparable manner the spinal, the nervous, and the muscle systems. Remarkably, each system demonstrates and maintains the condition of the other.
Relationship between hip muscle imbalance and occurrence of low	*Am J Phys Med Rehabil.* 2001 Aug;80(8):572-7.

back pain in collegiate athletes: a prospective study, Nadler SF, Malanga GA, Feinberg JH, Prybicien M, Stitik TP, DePrince M.	**OBJECTIVE:** To assess whether athletes with strength imbalance of the hip musculature would be more likely to require treatment for low back pain (LBP) over the ensuing year. **DESIGN:** The study population included 163 National Collegiate Athletic Association Division I college athletes (100 males and 63 females) undergoing preparticipation sports physicals. Institutional review board approval was obtained to acquire and analyze hip muscle strength data. A commercially available dynamometer (Chatillon, Lexington, KY) incorporated into a specially designed anchoring station was used for testing the hip extensors and abductors. The maximum force generated for the hip abductors and extensors was used to calculate a percentage difference between the right and left hip extensors and abductors. Treatment of athletes by the athletic trainers for LBP unrelated to blunt trauma over the ensuing year was recorded. **RESULTS:** Of all athletes, 5 of 63 females and 8 of 100 males required treatment for LBP. Logistic regression analysis indicated that for female athletes, the percentage difference between the right and left hip extensors was predictive of whether treatment for LBP was required over the ensuing year ($P = 0.05$). There was no significant association noted for the percentage difference between the right and left hip abductors in females and for the percentage difference between both the right and left hip abductors and right and left hip extensors in males requiring treatment for LBP. **CONCLUSIONS:** These data support our results from our previous cohort study, **adding validity to the concept of hip muscle imbalance being associated with LBP occurrence in female athletes. This research further supports the need for the assessment and treatment of hip muscle imbalance in individuals with LBP.** **Comment:** The correlation between “inhibited” or “weak” MMT findings and low back pain has been established in much of the research literature. This paper shows that there is a construct validity and reliability in employing MMT testing in patients with low back pain.
Comparison of effects of spinal manipulation and massage on motoneuron excitability, Dishman J, Bulbulian R.	*Electromyogr Clin Neurophysiol.* 2001;41:97-106 **Abstract:** The purpose of this study was to compare the magnitude and duration of motoneuron inhibition occurring as a sequel to spinal manipulation or paraspinal and limb massage. The physiologic mechanisms involved in spinal manipulative therapy and massage therapy are largely unknown. One possible hypothesis is based upon the theory that these two distinct and different modalities may attenuate the activity of alpha motoneurons. Both modalities have been reported to produce short-term inhibition of motoneurons. Asymptomatic volunteers were randomly assigned to either a spinal manipulation, massage, or control group. Baseline tibial nerve H-reflex amplitudes were obtained prior to the application of either lumbosacral spinal manipulation or paralumbar and limb massage. Post-interventional H-reflex recordings were recorded immediately following the application of either modality. Spinal manipulation significantly ($p < 0.05$) attenuated alpha motoneuronal activity immediately post-therapy, as measured by the amplitude of the tibial nerve H-reflex. Massage subjects exhibited no significant reduction in motoneuronal activity immediately following administration. Spinal manipulation produced a transient attenuation of alpha motoneuronal excitability. Paraspinal and limb massage did not inhibit the motoneuron pool as measured immediately post-therapy. These findings support the supposition that spinal manipulation procedures lead to short-term inhibitory effects on motoneuron excitability to a greater magnitude than massage.
Changes in strength over time among polio survivors, Klein MG, Whyte J, Keenan MA, Esquenazi A, Polansky M.	*Arch Phys Med Rehabil,* 2000 Aug;81(8):1059-64. **Abstract:** OBJECTIVE: To study changes in the strength of different muscle groups in polio survivors over a period of approximately 9 months. DESIGN: Longitudinal study. SETTING: Moss Rehabilitation Research Institute. PARTICIPANTS: One hundred twenty subjects (57 men, 63 women) were studied on three occasions, each 3 to 5 months apart. Subjects were recruited through the Einstein-Moss Post-Polio Management Program. newspaper advertisements, and polio support groups. MAIN OUTCOME MEASURES: Isometric strength of 30 muscle groups (16 in upper extremities, 14 in lower extremities)

	was measured, using a hand-held dynamometer. RESULTS: Data were analyzed in two separate groups: upper-extremity muscles and lower-extremity muscles. Results for the upper-extremity muscles revealed evidence of a significant deterioration in strength. The amount of deterioration differed among muscles and increased with age. There was also evidence of deterioration in strength in the flexor muscles in the ankle, hip, and knee. However, the rate of deterioration in these muscles was not strongly related to age, time since polio, gender, symptom status, or history of residual weakness. CONCLUSIONS: Strength is deteriorating among polio survivors at a rate higher than that associated with normal aging. This deterioration is not occurring in the extensor, or so-called "weight-bearing" muscles, but is occurring in many of the upper-extremity muscle groups and in the flexor muscles in the lower extremities. **Comment:** This paper demonstrates what has been long hypothesized (and demonstrated clinically) in chiropractic and AK to be the case, i.e. that neurological function deteriorates in disease states, and that the muscular system reflects this change in state, thus serving as a “somatic window” or “representational system” of neurological function.
Changes in strength over time among polio survivors, Klein MG, Whyte J, Keenan MA, Esquenazi A, Polansky M.	*Arch Phys Med Rehabil*, 2000 Aug;81(8):1059-64. **Abstract:** OBJECTIVE: To study changes in the strength of different muscle groups in polio survivors over a period of approximately 9 months. DESIGN: Longitudinal study. SETTING: Moss Rehabilitation Research Institute. PARTICIPANTS: One hundred twenty subjects (57 men, 63 women) were studied on three occasions, each 3 to 5 months apart. Subjects were recruited through the Einstein-Moss Post-Polio Management Program. newspaper advertisements, and polio support groups. MAIN OUTCOME MEASURES: Isometric strength of 30 muscle groups (16 in upper extremities, 14 in lower extremities) was measured, using a hand-held dynamometer. RESULTS: Data were analyzed in two separate groups: upper-extremity muscles and lower-extremity muscles. Results for the upper-extremity muscles revealed evidence of a significant deterioration in strength. The amount of deterioration differed among muscles and increased with age. There was also evidence of deterioration in strength in the flexor muscles in the ankle, hip, and knee. However, the rate of deterioration in these muscles was not strongly related to age, time since polio, gender, symptom status, or history of residual weakness. CONCLUSIONS: Strength is deteriorating among polio survivors at a rate higher than that associated with normal aging. This deterioration is not occurring in the extensor, or so-called "weight-bearing" muscles, but is occurring in many of the upper-extremity muscle groups and in the flexor muscles in the lower extremities. **Comment:** This paper demonstrates what has been long hypothesized (and demonstrated clinically) in chiropractic and AK to be the case, i.e. that neurological function deteriorates in disease states, and that the muscular system reflects this change in state, thus serving as a “somatic window” or “representational system” of neurological function.
Integrated jaw and neck function in man. Studies of mandibular and head-neck movements during jaw opening-closing tasks, Zafar H	*Swed Dent J Suppl*, 2000;(143):1-41. **Abstract:** This investigation was undertaken to test the hypothesis of a functional relationship between the human temporomandibular and craniocervical regions. Mandibular and head-neck movements were simultaneously recorded in healthy young adults using a wireless optoelectronic system for three dimensional movement recording. The subjects were seated in an upright position without head support and were instructed to perform maximal jaw opening-closing movements at fast and slow speed. As a basis, a study was undertaken to develop a method for recording and analysis of mandibular and head-neck movements during natural jaw function. A consistent finding was parallel and coordinated head-neck movements during both fast and slow jaw opening-closing movements. The head in general started to move simultaneously with or before the mandible at the initiation of jaw opening. Most often, the head attained maximum velocity after the mandible. A high degree of spatiotemporal consistency of mandibular and head-neck movement trajectories

	was found in successive recording sessions. The head movement amplitude and the temporal coordination between mandibular and head-neck movements were speed related but not the movement trajectory patterns. Examination of individuals suffering from temporomandibular disorders and whiplash associated disorders (WAD) showed, compared with healthy subjects, smaller amplitudes, a diverse pattern of temporal coordination but a similar high degree of spatiotemporal consistency for mandibular and head-neck movements. In conclusion, the results suggest the following: A functional linkage exists between the human temporomandibular and craniocervical regions. Head movements are an integral part of natural jaw opening-closing. "Functional jaw movements" comprise concomitant mandibular and head-neck movements which involve the temporomandibular, the atlanto-occipital and the cervical spine joints, caused by jointly activated jaw and neck muscles. Jaw and neck muscle actions are elicited and synchronized by neural commands in common for both the jaw and the neck motor systems. These commands are preprogrammed, particularly at fast speed. In the light of previous observations of concurrent jaw and head movements during foetal yawning, it is suggested that these motor programs are innate. Neural processes underlying integrated jaw and neck function are invariant both in short- and long-term perspectives. Integrated jaw and neck function seems to be crucial for maintaining optimal orientation of the gape in natural jaw function. Injury to the head-neck, leading to WAD may derange integrated jaw-neck motor control and compromise natural jaw function. **Comment:** In AK examination and treatment, the complexity of the TMJ apparatus is recognized. The TMJ is part of a complex system including the bones of the skull and cervical spine, the mandible and hyoid bone, the related muscle attachments and other soft tissues, and neurologic and vascular components. This complex is often referred to as the stomatognathic system. The use of AK methods, especially challenge and therapy localization, greatly assists the practitioner in finding concealed or hidden TMJ problems.
Expanding the Neurological Examination Using Functional Neurologic Assessment Part I: Methodological Considerations, Motyka, T., Yanuck, S.	*International Journal of Neuroscience*. 1999; 97:61-76. The authors discuss AK as a clinical measure of neurologic function. A review of the literature reveals methodological problems with previous studies of AK as a form of neurologic assessment. The authors discuss the problems with research designs that do not reflect the clinical practice of AK which are common in the literature. They outline principles of AK and recommend that future research reflect more accurately the clinical practice of functional neurologic assessment and AK.
Expanding the Neurological Examination Using Functional Neurologic Assessment Part II: Neurologic Basis of Applied Kinesiology, Schmitt, W., Yanuck, S.	*International Journal of Neuroscience*. 1999; 97:77-108. This paper proposes a neurologic model for many AK procedures. Manual assessment of muscular function is used to identify changes associated with facilitation and inhibition, in response to the introduction of sensory receptor-based stimuli. Muscle testing responses to sensory stimulation of known value are compared with usually predictable patterns based on known neuroanatomy and neurophysiology, guiding the clinician to an understanding of the functional status of the patient's nervous system. The proper understanding of the neurophysiologic basis of muscle testing procedures will assist in the design of further investigations into AK. Accordingly, the neurophysiologic basis and proposed mechanisms of these methods are reviewed.
The effects of a pelvic blocking procedure upon muscle strength: a pilot study, Unger, J.	*Chiropractic Technique*, Nov 1998;10(4) Using a hand-held force transducer, the unit was interposed between the examiner’s hand and the subject’s appendage being tested. The unit used in this study was interfaced with a computer program that gives statistical analysis for repeated testing reliability. This study found a significant increase in strength in the pectoralis (sternal and clavicular divisions tested separately), anterior deltoid, latissimus dorsi, psoas, tensor fascia lata, adductor, and

	gluteus medius muscles following the correction of a category II pelvic fault.
Muscle Test Comparisons of Congruent and Incongruent Self-Referential Statements, Monti, D., Sinnott, J., Marchese, M., Kunkel, E., Greeson, J.	*Perceptual and Motor Skills*. 1999, 88:1019-1028. This study investigated differences in manual muscle test outcomes after exposure to congruent and incongruent semantic stimuli. Muscle testing with a computerized dynamometer was performed on the deltoid muscle group of 89 healthy college students after repetitions of congruent (true) and incongruent (false) self-referential statements. The order in which statements were repeated was controlled by a counterbalanced design. The combined data showed that approximately 17% more total force over a 59% longer period of time could be endured when subjects repeated semantically congruent statements ($p<.001$). Order effects were not significant. Over all, significant differences were found in muscle test responses between congruent and incongruent semantic stimuli.
Correlation of Applied Kinesiology Muscle Testing Findings with Serum Immunoglobulin Levels for Food Allergies, Schmitt, W., Leisman, G.	*International Journal of Neuroscience*. 1998; 96:237-244. This study showed a high degree of correlation between AK procedures used to identify food allergies and serum levels of immunoglobulins for those foods. AK methods in this study consisted of stimulation of taste bud receptors with various foods, and observation of changes in manual muscle testing that resulted. The patient was judged to be allergic to foods that created a disruption of muscle function. Blood drawn subsequently showed that patients had antibodies to the foods which were found to be allergenic through AK assessment.
EMG recordings of abdominal and back muscles in various standing postures: validation of a biomechanical model on sacroiliac joint stability, Snijders, C.J., Ribbers, M.T., de Bakker, H.V., Stoeckart, R., Stam, H.J.	*J Electromyogr Kinesiol*, 1998;8:205-14 **Abstract:** In a biomechanical model we described that for stability of the flat sacroiliac joints (SIJ) muscle forces are required which press the sacrum between the two hip bones (self-bracing). Shear loading of these joints is caused by gravity and longitudinally oriented muscles. Protection against shearing can come from transversely oriented muscles like the internal oblique (OI) abdominal muscles. For validation we used standing postures with significantly more or less OI activity compared to activity in a standardized erect standing reference posture. OI activity decreased significantly when (a) resting on one leg (the contralateral), as can be observed at bus stops, (b) tilting the pelvic backward and (c) applying a pelvic belt. We explain this decrease of OI activity by, respectively, decrease of gravity load, decrease of load from the psoas major muscles, and a substitute of self-bracing. The outcome of this study is in line with the biomechanical model on SIJ stability. Clinical relevance of this study regards aspecific low back pain and is found in the effect of the use of a pelvic belt, of a trunk position as adopted when wearing a small rucksack and of the benefit of exercising trunk muscles in extension and torsion.
Disturbed eye movements after whiplash due to injuries to the posture control system, Gimse R, Tjell C, Bjorgen IA, Saunte C.	*J Clin Exp Neurophychol*, 1996;18(2):178-86. **Abstract:** Self-reports after whiplash often indicate associations with vertigo and reading problems. Neuropsychological and otoneurological tests were applied to a group of whiplash patients (n = 26) and to a carefully matched control group. The whiplash group deviated from the control group on measures of eye movements during reading, on smooth pursuit eye movements with the head in normal position, and with the body turned to the left or to the right. Clinical, caloric, and neurophysiological tests showed no injury to the vestibular system or to the CNS. Test results suggest that injuries to the neck due to whiplash can cause distortion of the posture control system as a result of disorganized neck proprioceptive activity. **Comment:** Central to the concept of applied kinesiology chiropractic evaluation and treatment is the consideration that the senses of seeing, hearing, smelling, tasting, feeling,

	and balance are not simple, specific sensations; rather they are sensory systems closely interrelated among themselves and intimately linked with motor functions. In applied kinesiology chiropractic methodology, a means for testing the integration of the muscles in the body with the visual reflexes has been termed *ocular lock*. It demonstrates the failure of the eyes to work together on a binocular basis through the cardinal fields of gaze. This is usually not gross pathology of cranial nerves III, IV, and VI; rather it is poor functional organization. Mechanical irritation of cranial nerves III, IV, or VI (usually VI) may be responsible for disturbed binocular function leading to discordant sensory inputs from the visual righting reflex. When the eyes are turned in a specific direction, a previously strong indicator muscle will weaken when the ocular lock test is positive, and there is probably disturbance in the visual righting, vestibulo-ocular, or opto-kinetic reflexes.
A preliminary inquiry into manual muscle testing response in phobic and control subjects exposed to threatening stimuli	*J Manipulative Physiol Ther.* 1996 Jun;19(5):310-6. **Objective:** To determine phobic and non-phobic subject response to a provocative threat stimulus and to determine variables that confound the response. **Design:** Randomized blind examiner test-retest of randomized phobic and control subjects with qualitative, semistructured, information postintervention interview. **Setting:** Private chiropractic clinic. Subjects: Thirteen phobic individuals, as determined by the Diagnostic and Statistical Manual of Mental Disorders, Third Edition – Revised (DSM-III-R), and 14 control volunteer subjects. **Intervention:** Manual muscle testing was performed while each subject viewed a threat stimulus (i.e., a cue word on a printed card). The results were recorded as "weak" or "strong." **Results:** The analysis of the data demonstrates poor inter- (K = -0.19) and intraexaminer reliability (K = -0.14- +0.29). The test for independence for valid muscle testing was strong for both examiners (p = .462, p = 1.00) When confounding variables were corrected for, the validity of muscle testing increased to 91%. **Conclusion:** This preliminary inquiry demonstrates the need for musculoskeletal, attentional and presensitized subject variables to be controlled to ascertain if muscle testing can be reliably used as a tool to identify emotional arousal.
Electromyographic Effects of Fatigue and Task Repetition on the Validity of Estimates of Strong and Weak Muscles in Applied Kinesiology Muscle Testing Procedures, Leisman, G., et al.	*Perceptual and Motor Skills.* 1995; 80:963-977. Abstract: The study investigated the effects of fatigue and task repetition on the relationship between integrated electromyogram and force output during subjective clinical testing of upper extremity muscles. Muscles were studied under two conditions differing in nature and duration of constant force production (SHORT-F) and (LONG-F). The findings included a significant relationship between force output and integrated EMG, a significant increase in efficiency of muscle activity with task repetition, and significant difference between Force/integrated EMG ratios for muscles labeled "Strong" and "Weak" in the LONG-F condition. This supports Smith's 1974 notion that practice results in increased muscular efficiency. With fatigue, integrated EMG activity increased strongly and functional (force) output of the muscle remained stable or decreased. Fatigue results in a less efficient muscle process. Muscles subjectively testing "Weak" or "Strong" yield effects significantly different from fatigue.
Sacroiliac joint manipulation decreases the H-reflex, Murphy, B.A., Dawson, N.J., Slack, J.R.	*Electromyogr Clin Neurophysiol*, 1995;35:87-94 **Abstract:** Joint manipulation is widely utilized clinically to decrease pain and increase the range of motion of joints displaying limited mobility. Evidence of efficacy is based on subjective reports of symptom improvement as well as on the results of clinical trials. Experiments were designed to determine whether or not sacroiliac joint manipulation affects the amplitude of the Hoffman (H) reflex. Surface EMG recordings of the reflex response to electrical stimulation of the tibial nerve in the popliteal fossa were made from the soleus muscle. The averaged amplitudes of H-reflexes were compared on both legs before and after either sacroiliac joint manipulation or a sham procedure. H-reflex

	amplitude was significantly decreased (12.9%) in the ipsilateral leg ($p < 0.001$) following a sacroiliac joint manipulation while there was no significant alteration following the sham intervention. There was no significant alteration in reflex excitability in the contralateral leg to the sacroiliac joint manipulation. To further investigate the mechanism of these reflex alterations, the local anesthetic cream EMLA (Astra Pharmaceuticals) was applied to the skin overlying the sacroiliac joint and the experiments were repeated on a different group of subjects. This was intended to determine if excitation of cutaneous afferents was responsible for the reflex excitability changes. There was still a significant decrease in reflex excitability (10.6%) following sacroiliac joint manipulation ($p < 0.001$). These findings indicate that joint manipulation exerts physiological effects on the central nervous system, probably at the segmental level. The fact that the changes persisted in the presence of cutaneous anesthesia suggests that the reflex changes are likely to be mediated by joint and/or muscle afferents. **Comment:** This study offers further elucidation of the finding of the physiological response of muscles to sacroiliac manipulation. One basic physiologic response to spinal manipulative therapy is a transient decrease or increase in motoneuron activity as assessed by the Hoffmann reflex (H-reflex) technique, depending upon the patients neuromuscular status at the time of measurement. The H-reflex technique involves peripheral stimulation of the Ia-afferent feedback pathway to assess the excitability of the alpha motoneuron. The MMT in AK evaluates the same neurological mechanism. This study shows that the clinical efficacy of SMT may involve a change in motoneuron activity which, in turn, may lead to a reduction in hypertonic as well as an increase in hypotonic muscles. Thus, a basic neurophysiologic response to SMT is muscular response to treatment.
Shoulder weakness in professional baseball pitchers, Magnusson SP, Gleim GW, Nicholas JA.	*Med Sci Sports Exerc.* 1994 Jan;26(1):5-9. **Abstract:** The purposes of this study were to: 1) compare shoulder range of motion and strength in professional baseball pitchers (N = 47) compared with age-matched controls (N = 16), and 2) examine the relationship of injury history to strength and range of motion. Based on injury history pitchers were categorized as: 1) none (N = 26), 2) injury requiring conservative intervention (N = 9), or 3) injury requiring surgical intervention (N = 12). Range of motion was measured for internal rotation (IROM) and external rotation (EROM). Eccentric strength was measured by hand-held dynamometer for internal rotation (IR), external rotation (ER), abduction (ABD), and supraspinatus muscle (SUP) strength. Injury history had no effect on strength and range of motion. Dominant EROM was greater in pitchers, $P < 0.0001$, and controls, $P < 0.05$, with pitchers having greater EROM motion bilaterally, $P < 0.0001$. **Pitchers were weaker in SUP on the dominant vs nondominant side, $P < 0.0001$, and on the dominant side for weight adjusted ER, ABD, $P < 0.01$, and SUP, $P < 0.0001$, compared with controls. In conclusion, dominance and pitching resulted in soft tissue adaptation. Pitchers displayed weakness in three of four tests by comparison with controls, suggesting that the demands of pitching are insufficient to produce eccentric strength gains and may in fact lead to weakness. Dominant-side SUP weakness in pitchers may reflect subclinical pathology or chronic fatigue.**
Isokinetic Muscle Testing: Is It Clinically Useful?, Almekinders LC, Oman J.	*J Am Acad Orthop Surg*, 1994 Jul;2(4):221-225. **Abstract**: The use of computer-driven muscle-testing devices has become increasingly popular during the past two decades. This expensive equipment allows evaluation of muscles and muscle groups in an isokinetic manner. Isokinetic muscle testing is performed with a constant speed of angular motion but variable resistance. Isokinetic dynamometers have been shown to produce relatively reliable data when testing simple, uniaxial joints, such as the knee, as well as when testing the spine in flexion and extension. Isokinetic strength data are generally not helpful in the diagnosis of orthopedic abnormalities. Isokinetic testing can be helpful during the rehabilitation of orthopedic patients, since it allows easy monitoring of progress. It also enables the patient to work on muscle

	rehabilitation in a controlled manner at higher speeds than are possible with more conventional exercise equipment. An isokinetic rehabilitation program can be easily tailored with concentric and eccentric components that closely resemble muscle actions during occupational and sports activities.
Postural control in young and elderly adults when stance is perturbed: kinematics, Alexander, N. B, Shepard, N, Gu, MJ, Schultz, A.	*Journal of Gerontology*, 1992; 47:M79-M87. **Abstract:** Increased postural sway and falling are associated with aging and are likely related to problems with postural control in the elderly. We investigated the motions of individual body segments in 24 healthy young adults and 15 healthy elderly adults (mean ages 26 and 72) in response to four tasks: (a) standing with feet flat on an anteriorly accelerating platform (Flat Translation); standing on a narrow beam support that was (b) stationary (Beam Standing) and (c) accelerating anteriorly (Beam Translation); and (d) standing on a rotatable but otherwise stationary springboard (Springboard Standing). An optoelectronic camera system was used to measure rotations of body segments, particularly regarding their maximum excursions, time to first rotation response, direction of initial rotation, and time to first rotation reversal. In general, larger rotation excursions were noted in the elderly compared to the young group, particularly in the Beam Standing and Beam Translation tasks, but the magnitude of rotation difference was small. All rotation magnitudes were well within the available ranges of motion of the body joints. In both excursion magnitudes and directions of initial rotation, the elderly showed greater variability than the young. In the Beam Translation task, the elderly group, compared to the young, tended to rotate their upper body segments more than in the Flat Translation task. These data suggest that healthy elderly adults with no apparent musculoskeletal or neurological impairments have small but consistent differences in postural control kinematics, particularly when more challenging conditions are presented. Moreover, these data provide the basis for biomechanical analyses of joint torques and other dynamic requirements of these responses. **Comment:** Manual muscle testing is the method of testing functional neurology and postural mechanisms in applied kinesiology. Normally there is predictable facilitation and inhibition of muscle function. When there is not, applied kinesiology testing methods are employed to discover and correct the factors responsible for the disturbance in predictable muscle function. The importance of restoring normal function in elderly patients is demonstrated by the postural kinematic disturbances of the patients in this study.
Intrarater reliability of manual muscle test (Medical Research Council scale) grades in Duchenne's muscular dystrophy, Florence JM, Pandya S, King WM, Robison JD, Baty J, Miller JP, Schierbecker J, Signore LC.	*Phys Ther*. 1992 Feb;72(2):115-22; discussion 122-6 **Abstract: The purpose of this study was to document the intrarater reliability of manual muscle test (MMT) grades in assessing muscle strength in patients with Duchenne's muscular dystrophy (DMD).** Subjects were 102 boys, aged 5 to 15 years, who were participating in a double-blind, multicenter trial to document the effects of prednisone on muscle strength in patients with DMD. Four physical therapists participated in the study. Two identical (duplicate) evaluations were performed within 5 days of each other by the same examiner initially and after 6 and 12 months of treatment. A total of 18 muscle groups were tested on each patient, 16 of them bilaterally, using a modification of the Medical Research Council scale. Reliability of muscle strength grades obtained for individual muscle groups and of individual muscle strength grades was analyzed using Cohen's weighted Kappa. **The reliability of grades for individual muscle groups ranged from .65 to .93, with the proximal muscles having the higher reliability values. The reliability of individual muscle strength grades ranged from .80 to .99, with those in the gravity-eliminated range scoring the highest. We conclude the MMT grades are reliable for assessing muscle strength in boys with DMD when consecutive evaluations are performed by the same physical therapist.**
The pain-adaptation model: a	*Canadian Journal of Physiology and Pharmacology*, 1991;69:683-694.

discussion of the relationship between chronic musculoskeletal pain and motor activity, Lund, J.P., et al.	**Abstract:** Articles describing motor function in five chronic musculoskeletal pain conditions (temporomandibular disorders, muscle tension headache, fibromyalgia, chronic lower back pain, and postexercise muscle soreness) were reviewed. It was concluded that the data do not support the commonly held view that the pain of these conditions is maintained by some form of tonic muscular hyperactivity. Instead, it seems clear that in these conditions the activity of agonist muscles is often reduced by pain, even when this does not arise from the muscle itself. On the other hand, pain causes small increases in the level of activity of the antagonist. As a consequence of these changes, force production and the range and velocity of movement of the affected body part are often reduced. To explain how such changes in the behavior come about, we propose a neurophysiological model based on the phasic modulation of excitatory and inhibitory interneurons supplied by high-threshold sensory afferents. We suggest that the "dysfunction" that is characteristic of several types of chronic musculoskeletal pain is a normal protective adaptation and is not a cause of pain. **Comment:** This paper articulates with fascinating similarity one of the major hypotheses in AK, namely that physical, chemical, or emotional imbalances produce secondary muscle dysfunction, specifically a muscle inhibition (usually followed by overfacilitation of an opposing muscle). Muscles lose function and become inhibited because of structural problems like trauma or chemical imbalance due to a hormonal influence or mental/emotional stress.
Failure of the musculo-skeletal system may produce major weight shifts in forward and backward bending, Goodheart, G.	*Proc Inter Conf Spinal Manip,* Washington, DC;May 1990:399-402 Forty patients were evaluated for pre- and post-treatment weight balance. Of the 40 patients, only one had minimal changes in weight upon two scales beneath the feet when both flexing and extending the spine. The treatment protocol employed (applied kinesiology methods) proved to balance the aberrant patterns of weight distribution during flexion and extension of the spine.
Cybernetic Model of Psychophysiologic Pathways: II. Consciousness of Effort and Kinesthesia, Leisman, G.	*Journal of Manipulative and Physiological Therapeutics*. 1989; 12(3):174-191. **Abstract:** This paper describes a series of experiments directed toward the following questions: a) do signals from musculotendinous receptors reach consciousness?, and b) does feed-forward information of muscular force and expected extent of voluntary movement exist? To answer these questions, data from voluntary compression of springs and strain-gauge have been analyzed in healthy young subjects. By successive elimination of information from other sources, it was possible to verify that receptors in muscles and tendons do signal movement magnitude and muscular tension to the cerebral cortex, and that this information does reach consciousness. There also exists a feed-forward mechanism signaling parameters of voluntary contraction. However, it is unclear whether peripheral, subcortical or intracortical loops are directly involved.
Cybernetic Model of Psychophysiologic Pathways: III. Impairment of Consciousness of Effort and Kinesthesia, Leisman, G.	*Journal of Manipulative and Physiological Therapeutics*. 1989; 12(4):257-265. **Abstract:** It is unclear whether peripheral, subcortical or intracortical loops are directly involved between receptors in muscles and tendons and the cerebral cortex in signaling movement magnitude and muscular tension information. Previous experiments have indicated that this information does reach consciousness. Data from voluntary compression of springs and strain-gauge were analyzed in patients with unilateral lesions of the cerebral hemispheres. It was found that the perception of signals of muscular tension is abolished by lesions of the contralateral cortex near the central sulcus. It was concluded that the possibility exists of separate cortical projection areas for kinesthetic signals from muscles

	and from joints.
Influence of different static head-body positions on spinal lumbar interneurons in man: the role of the vestibular system, Rossi A, Mazzocchio R.	*ORL J Otorhinolaryngol Relat Spec,* 1988;50(2):119-26. **Abstract:** The present experiments were made in man with the aim of studying the possible influences of different head-body tilts on the activity of the interneurons Ia, Ib and the Renshaw cells functionally coupled to the soleus alpha-motoneurons. Subjects were seated on a chair, rotable with respect to the vertical axis, and were studied at 80 degrees and 40 degrees to the horizontal. The excitability of the soleus alpha-motoneurons slightly decreased when the body was placed at 40 degrees of backward inclination whereas the Renshaw cell activity showed a reinforcement of inhibition on the same motoneurons. The reciprocal inhibition from the anterior tibial to the soleus muscle increased at 40 degrees of backward inclination with respect to the control values at 80 degrees. Finally, short-latency homonymous facilitation and inhibition showed no significant change in relation to body position. The results indicate that different head-body positions are able to modify the bias of spinal interneurons in man. We discuss the hypothetical role of the vestibular system in producing the effects seen. **Comment:** The labyrinthine and visual righting reflexes may be disturbed by joint or muscle problems in the neck, as well as by cranial faults that may result from either whiplash dynamics or a blow to the head during an automobile accident or other head and neck trauma. It is hypothesized in AK that temporal bone cranial faults can result in imbalance in one or both sternocleidomastoid and upper trapezius muscles due to mechanical irritation of cranial nerve XI as it exits the skull through the jugular foramina, and could thereby disturb the biomechanics of the joints in the neck. This phenomenon is found on a daily basis in the clinical setting, and muscles anywhere in the body may be facilitated by proper cranial therapy. Anatomical distortions of the geometry of the vestibular mechanism within the temporal bones (producing a tilt in the angular geometry of the semicircular canals) may create discordant sensory input into the CNS compared to that coming into it from the spinal joints and muscles, thereby producing poor stability and deficient motor activity.
New diagnostic and therapeutic approach to thyroid-associated orbitopathy based on applied kinesiology and homeopathic therapy, Moncayo, R., Moncayo, H., Ulmer, H., Kainz, H.	*J Altern Complement Med*, 2004 Aug;10(4):643-50. **Objectives:** To investigate pathogenetic mechanisms related to the lacrimal and lymphatic glands in patients with thyroid-associated orbitopathy (TAO), and the potential of applied kinesiology diagnosis and homeopathic therapeutic measures. **Design:** Prospective. **Settings/location:** Thyroid outpatient unit and a specialized center for complementary medicine (WOMED, Innsbruck; R.M. and H.M.). **Subjects:** Thirty-two (32) patients with TAO, 23 with a long-standing disease, and 9 showing discrete initial changes. All patients were euthyroid at the time of the investigation. **Interventions:** Clinical investigation was done, using applied kinesiology methods. Departing from normal reacting muscles, both target organs as well as therapeutic measures were tested. Affected organs will produce a therapy localization (TL) that turns a normal muscle tone weak. Using the same approach, specific counteracting therapies (i.e., tonsillitis nosode and lymph mobilizing agents) were tested. **Outcome measures:** Change of lid swelling, of ocular movement discomfort, ocular lock, tonsil reactivity and Traditional Chinese Medicine criteria including tenderness of San Yin Jiao (SP6) and tongue diagnosis were recorded in a graded fashion. **Results:** Positive TL reactions were found in the submandibular tonsillar structures, the tonsilla pharyngea, the San Yin Jiao point, the lacrimal gland, and with the functional ocular lock test. Both Lymphdiaral® (Pascoe, Giessen, Germany) and the homeopathic preparation chronic tonsillitis nosode at a C3 potency (Spagyra,® Grödig, Austria) counteracted these changes. Both agents were used therapeutically over 3–6 months, after which all relevant parameters showed improvement. **Conclusions:** Our study demonstrates the involvement of lymphatic structures and flow in the pathogenesis of TAO. The tenderness of the San Yin Jiao point correlates to the abovementioned changes and should be included in the clinical evaluation of these patients.

Applied kinesiology and dentistry, Goodheart, G.J.	*Basal Facts,* 9(2);1987:69-73 **Abstract:** This paper presents the applied kinesiology approach for treating structurally based disorders of the temporomandibular joint through an integrated approach to patient care. This approach may require close cooperation between dental orthopedic and chiropractic professionals in evaluating and treating patients. Dental occlusion is suggested to be part of a larger pattern of function that includes the spine, pelvis, cranium, and neuromuscular systems that span them. The jaws, cranium, spine and pelvis are considered as interdependent parts of the whole body system. The AK protocol for evaluation of these factors is presented, and specific techniques for the diagnosis and treatment the musculature of the stomatognathic system are offered.
Correlation of objective measure of trunk motion and muscle function with low-back disability ratings, Triano, J, Schultz, A	*Spine,* 1987;12:561-5 **Abstract:** A study was undertaken to examine relations among some objective and subjective measures of low-back-related disability in a group of 41 low-back pain patients and in seven pain-free control subjects. Subjective measures of disability were obtained by Oswestry patient questionnaires. Oswestry disability score related significantly (P less than 0.001) to presence or absence of relaxation in back muscles during flexion. Mean trunk strength ratios were inversely related to disability score (P less than .05), and trunk mobility was meaningfully reduced (P less than .01). Despite loss of motion, a large enough excursion was observed to predict presence of back muscle relaxation. These findings imply that myoelectric signal levels, trunk strength ratios, and ranges of trunk motion may be used as objective indicators of low-back pain disability. **Comment:** The findings in this study imply that muscle function, as measured by EMG, MMT, and ranges of trunk motion may be used as objective indicators of low-back pain disability.
Applied kinesiology and colon health, White, P.	*Basal Facts,* 1985;7(2):143-50. **Abstract:** A review of the physiology of the gastro-intestinal tract is given, as well as the anatomical and bio-chemical factors that may disturb normal function in the colon. A protocol of AK evaluation is offered for the examination of the gastro-intestinal tract. The ileocecal valve's importance for normal colon health is described, and dietary and nutritional advice is given for disturbances in the colon.
Uses of applied kinesiology for dentists, Walther, D.S.	*Basal Facts,* 1985;7(2):133-41. **Abstract:** This paper also describes the applied kinesiology approach for treating structurally based disorders of the temporomandibular joint through an integrated approach to patient care. This approach may require close cooperation between dental orthopedic and chiropractic professionals in evaluating and treating patients. Dental occlusion is suggested to be part of a larger pattern of function that includes the spine, pelvis, cranium, and neuromuscular systems that span them. The jaws, cranium, spine and pelvis are considered as interdependent parts of the whole body system. The AK protocol for evaluation of these factors is presented, and specific techniques for the diagnosis and treatment of the musculature of the stomatognathic system are offered.
Physical measurements as risk indicators for low back trouble over a one year period, Biering-Sorensen, F.	*Spine,* 1984;9:106-19 **Abstract:** Of all 30-, 40-, 50-, and 60-year-old inhabitants of Glostrup, a suburb of Copenhagen, 82% (449 men and 479 women) participated in a general health survey, which included a thorough physical examination relating to the lower back. The examination was constituted of anthropometric measurements, flexibility/elasticity measurements of the back and hamstrings, as well as tests for trunk muscle strength and endurance. The

	reproducibility of the tests was found to be satisfactory. Twelve months after the physical examination 99% of the participants completed a questionnaire sent by mail concerning low back trouble (LBT) in the intervening period. The prognostic value of the physical measurements was evaluated for first-time experience and for recurrence or persistence of LBT by analyses of the separate measurements and discriminant analyses. The main findings were that good isometric endurance of the back muscles may prevent first-time occurrence of LBT in men and that men with hypermobile backs are more liable to contract LBT. Recurrence or persistence of LBT was correlated primarily to the interval since last LBT-episode: the more LBT, the shorter the intervals had been. Weak trunk muscles and reduced flexibility/elasticity of the back and hamstrings were found as residual signs, in particular, among those with recurrence or persistence of LBT in the follow-up year.
Applied dental kinesiology: temporomandibular joint dysfunction, Glassley DP	*Basal Facts*, 1983;5(2):65-6
Usefulness of electrophysiological studies in the diagnosis of lumbosacral root disease, Tonzola R, Ackil A, Shahani B, Young R.	*Ann Neurol* 1981;9:305-308 **Abstract:** Clinical, electrophysiological, and myelographic findings were correlated in 57 patients with the clinical diagnosis of lumbosacral root disease. Conventional motor and sensory (including sural nerve) conduction studies were normal in all patients. Electromyography, late response studies in different muscles of the lower extremity, the myelogram, or combinations of these tests were abnormal in 44 patients (77%). Of 36 patients (63%) with abnormal myelograms, 14 had normal electrophysiological studies. Twenty-nine (51%) had an abnormal electrophysiological or myelographic finding; although 8 patients in this group had a normal myelogram, 2 had an abnormal discogram and 1 an abnormal epidurogram. Electrophysiological or myelographic findings, in some cases both, correlated well with clinical signs and symptoms in 41 patients (72%). H-reflex and F response studies, when abnormal, helped in localizing a lesion in the appropriate root distribution. **Comment:** This study demonstrates that EMG shows better correlation with neurological examinations than CT scans or myelograms for nerve root disturbances in the lumbosacral spine. In other words, muscle dysfunction correlates better with lumbosacral nerve root injuries than CT scans or myelograms.
Neurophysiologic Inhibition of Strength Following Tactile Stimulation of the Skin, Nicholas, J.A., Melvin, M., Saraniti, A.J.	*American Journal of Sports Medicine*. 1980;8:181-186. **Abstract:** A modified shoulder abduction manual muscle test was incorporated in this study to demonstrate strength changes following tactile stimulation of the skin. Resistance was applied to the distal radioulnar joint and the stimulus (scratching) was applied inferior to the clavicle on the clavicular head of the pectoralis major muscle after maximum contraction. An electromechanical device quantified the isotonic (eccentric) measurements. A standard dynamometer system (Cybex II) was used to measure isometric strength. The nondominant side was used as the "control." Two populations, a normal (random) and a strong (athletic) group, were studied. Twenty-three persons (52% women, 48% men; mean age, 27 years; mean height, 67 inches (170 cm); and mean weight, 147 lb (66.7 kg)) were in the "normal" group and 17 persons (100% men; mean age, 25 years; mean height, 74 inches (188 cm); and mean weight, 215 lb (97.5kg)) were in the "strong" group. The random population showed a 19% decrease in strength following tactile stimulation as measured by the manual muscle testing unit; the athletic population showed a 17% decrease in strength. With the isometric measurements, the random population had an 8% decrease in mean strength following the scratch but the athletic population showed no significant decrease. The capability to quantify objectively manual muscle tests is discussed in relation to the importance of the proximal musculature.
Factors Influencing Manual	*Journal of Bone and Joint Surgery*. 1978; 60-A:186-190.

Muscle Tests in Physical Therapy, Nicholas, J. A., Sapega, A., Kraus, H., Webb, J.N.	**Abstract:** To determine whether it is the amount or the duration of the force applied manually by the tester, or both, that determines the tester's perception of the strength of the hip flexor or abductor muscles, an electromechanical device was designed which was placed between the tester's hand and the subject's limb. With the device we measured the force applied to the limb, the time interval during which it was applied, and the angular position of the limb during the entire test. In 240 such tests, the testers' ratings of the differences in strength between the right and left sides were correlated with seven variables involving force and time. It was found statistically that the impulse--that is, the duration of the tester's effort multiplied by the average applied force during each test--was the factor that most influenced the tester in the ratings.
Kinesiology and Dentistry, Goodheart, G.	*J Amer Soc Psychosomatic Disease,* 1976;6:16-18
A method of testing muscular strength in infantile Paralysis, Martin EG, Lovett RW.	*JAMA.* 1915 Oct 30; LXV(18):1512-3.
Certain aspects of infantile paralysis with a description of a method of muscle testing, Lovett RW, Martin EG.	*JAMA.*1916 Mar 4; LXVI(10):729-33.
Delayed trunk muscle reflex responses increase the risk of low back injuries, Cholewicki J, Silfies SP, Shah R, Greene HS, Reeves NP, Alvi K, Goldberg B	*Spine.* 2005 Dec 1;30(23):2614-20. **STUDY DESIGN:** Prospective observational study with a 2- to 3-year follow-up. **OBJECTIVES:** To determine whether delayed muscle reflex response to sudden trunk loading is a result of or a risk factor for sustaining a low back injury (LBI). **SUMMARY OF BACKGROUND DATA:** Differences in motor control have been identified in individuals with chronic low back pain and in athletes with a history of LBI when compared with controls. However, it is not known whether these changes are a risk for or a result of LBI. **METHODS:** Muscle reflex latencies in response to a quick force release in trunk flexion, extension, and lateral bending were measured in 303 college athletes. Information was also obtained regarding their personal data, athletic experience, and history of LBI. The data were entered into a binary logistic regression model to identify the predictors of future LBI. **RESULTS:** A total of 292 athletes were used for the final analysis (148 females and 144 males). During the follow-up period, 31 (11%) athletes sustained an LBI. The regression model, consisting of history of LBI, body weight, and the latency of muscles shutting off during flexion and lateral bending load releases, predicted correctly 74% of LBI outcomes. The odds of sustaining LBI increased 2.8-fold when a history of LBI was present and increased by 3% with each millisecond of abdominal muscle shut-off latency. On average, this latency was 14 milliseconds longer for athletes who sustained LBI in comparison to athletes who did not sustain LBI (77 [36] vs. 63 [31]). There were no significant changes in any of the muscle response latencies on retest following the injury. **CONCLUSIONS**: The delayed muscle reflex response significantly increases the odds of sustaining an LBI. These delayed latencies appear to be a preexisting risk factor and not the effect of an LBI.
Myotendinous alterations and effects of resistive loading in old age, Narici M, Maganaris C,	*Scand J Med Sci Sports.* 2005 Dec;15(6):392-401. **Abstract:** The loss of muscle mass associated with ageing only partly explains the

Reeves N. -- Institute for Biophysical and Clinical Research into Human Movement (IRM), Manchester Metropolitan University	observed decline in muscle strength. This paper provides evidence of the contribution of muscular, tendinous and neural alterations to muscle weakness in old age and discusses the complex interplay between the changes of the contractile tissue with those of the tendinous tissue in relation to the mechanical behavior of the muscle as a whole. Despite the considerable structural and functional alterations, the elderly musculoskeletal system displays remarkable adaptability to training in old age and many of these adverse effects may be substantially mitigated, if not reversed, by resistive loading. The interplay between these muscular and tendinous adaptations has an impact both on the length-force and force-velocity relationships of the muscle and is likely to affect the range of motion, rate of force development, maximum force development and speed of movement of the older individual.
Erector Spinae and Quadratus Lumborum Muscle Endurance Tests and Supine Leg-Length Alignment Asymmetry: An Observational Study, Knutson, G., Owens, E.	*J Manipulative Physiol Ther*, 2005;28(8):575-581 **Objective**: To determine if there is an association between supine leg-length alignment (LLA) asymmetry and the endurance of the erector spinae (ES) and quadratus lumborum (QL) muscles. **Methods:** Forty-seven subjects (21 women; average age, 36 years old) were tested for ES endurance using the Biering-Sorensen (B-S) test, and 69 (31 women; average age, 34.5 years) were tested for QL endurance. Subjects were examined for supine LLA and tested for ES and QL muscle endurance. The muscle endurance times were compared against those who did and did not demonstrate LLA asymmetry and the side of the "short leg." **Results:** In the B-S test, volunteers with LLA asymmetry (n = 27) had a mean endurance time of 89.7 seconds (SD, 43.3), and the no-LLA asymmetry group (n = 20) had a mean endurance time of 161.5 seconds (SD, 57.1), a significant difference (P < .001). In the QL test, after correction for the effects of sex and exercise, those with a right "short leg" (n = 22) had a right QL endurance time of 25.9 seconds (SE, 4.2) and a left QL endurance time of 34.7 seconds (SE, 4.3). The right QL endurance time was significantly different from those subjects with balanced legs (P = .001). Those with a left "short leg" (n = 20) had a left QL endurance time of 28.6 seconds (SE, 4.7) and a right QL endurance time of 38.1 seconds (SE, 4.5). Both QL endurance times were significantly different from those with balanced leg-length (P = .002 and .016, respectively). **Conclusion:** This study suggests that, using the B-S test, the group of volunteers who demonstrated a commonly used sign of subluxation/joint dysfunction, supine LLA asymmetry, had a decreased endurance times over those who did not. The QL endurance tests showed that the QL muscle ipsilateral to the supine short leg had significantly decreased endurance times over the same-side QL fatigue times in the no leg-length asymmetry group.
Spinal manipulation alters Electromyographic activity of paraspinal muscles: a descriptive study, DeVocht, J., Pickar, J., Wilder, D.	*J Manipulative Physiol Ther*, 2005;28(7):465-471 **Objective:** To examine the effect of spinal manipulation on electromyographic (EMG) activity in areas of localized tight muscle bundles of the low back. **Methods:** Surface EMG activity was collected from 16 participants in 2 chiropractic offices during the 5 to 10 minutes of the treatment protocol. Electrodes were placed over the 2 sites of greatest paraspinal muscle tension as determined by manual palpation. Spinal manipulation was administered to 8 participants using Activator protocol; the other 8 were treated using Diversified protocol. **Results:** Electromyographic activity decreased by at least 25% after treatment in 24 of the 31 sites that were monitored. There was less than 25% change at 3 sites and more than 25% increase at 4 sites. Multiple distinct increases and decreases were observed in many data plots. **Conclusion:** The results of this study indicate that manipulation induces a virtually immediate change, usually a reduction, in resting EMG levels in at least some patients with low back pain and tight paraspinal muscle bundles. In some cases, EMG activity increased during the treatment protocol and then usually, but not always, decreased to a level lower than the pretreatment level.
A hypothesis of chronic back pain: ligament subfailure injuries	*Eur Spine J.* 2005 Jul 27

lead to muscle control dysfunction, Panjabi M.	**Abstract:** Clinical reports and research studies have documented the behavior of chronic low back and neck pain patients. A few hypotheses have attempted to explain these varied clinical and research findings. A new hypothesis, based upon the concept that subfailure injuries of ligaments (spinal ligaments, disc annulus and facet capsules) may cause chronic back pain due to muscle control dysfunction, is presented. The hypothesis has the following sequential steps. Single trauma or cumulative microtrauma causes subfailure injuries of the ligaments and embedded mechanoreceptors. The injured mechanoreceptors generate corrupted transducer signals, which lead to corrupted muscle response pattern produced by the neuromuscular control unit. Muscle coordination and individual muscle force characteristics, i.e. onset, magnitude, and shut-off, are disrupted. This results in abnormal stresses and strains in the ligaments, mechanoreceptors and muscles, and excessive loading of the facet joints. Due to inherently poor healing of spinal ligaments, accelerated degeneration of disc and facet joints may occur. The abnormal conditions may persist, and, over time, may lead to chronic back pain via inflammation of neural tissues. The hypothesis explains many of the clinical observations and research findings about the back pain patients. The hypothesis may help in a better understanding of chronic low back and neck pain patients, and in improved clinical management. **Comment:** This is one of the most important articles published to date on the musculoskeletal aspects of the subluxation. Dr. Panjabi is the world's most published human biomechanical researcher, with 263 published articles to date. The hypothesis he presents in this paper places the functionality of muscles, as both a cause and a consequence of mechanoreceptor dysfunction in chronic back pain patients, at the center of a sequence of events that ultimately results in back pain. As a result of spinal subluxations, muscle coordination and individual muscle force characteristics, i.e. inhibited muscles on MMT, are disrupted. The injured mechanoreceptors generate corrupted transducer signals (that could be detected by EMG, dynamometers, or MMT), which lead to corrupted muscle response patterns produced by the neuromuscular control unit. This article is very important for those in the chiropractic profession who are evaluating the existence and the consequences of the subluxation. The key technical factor that makes AK indispensable in the detection of spinal dysfunction is the MMT that makes the detection of muscular imbalance verifiable.
Quantifying shoulder rotation weakness in patients with shoulder impingement, Tyler TF, Nahow RC, Nicholas SJ, McHugh MP. -- Nicholas Institute of Sports Medicine and Athletic Trauma, Lenox Hill Hospital, New York, NY, USA; PRO Sports Physical Therapy of Westchester, New York, NY, USA.	*J Shoulder Elbow Surg*. 2005 Nov-Dec;14(6):570-4. **Abstract:** The purpose of this study was to determine whether strength deficits could be detected in individuals with and without shoulder impingement, all of whom had normal shoulder strength bilaterally according to grading of manual muscle testing. Strength of the internal rotators and external rotators was tested isokinetically at 60 degrees /s and 180 degrees /s, as well as manually with a handheld dynamometer (HHD) in 17 patients and 22 control subjects. Testing was performed with the shoulder positioned in the scapular plane and in 90 degrees of shoulder abduction with 90 degrees of elbow flexion (90-90). The peak torque was determined for each movement. The strength deficit between the involved and uninvolved arms (patients) and the dominant and nondominant arms (control subjects) was calculated for each subject. Comparisons were made for the scapular-plane and 90-90 positions between isokinetic and HHD testing. Despite a normal muscle grade, patients had marked weakness (28% deficit, $P < .01$) in external rotators at the 90-90 position tested with the HHD. In contrast, external rotator weakness was not evident with isokinetic testing at the 90-90 position (60 degrees /s and 180 degrees /s, 0% deficit, $P = .99$). In control subjects, greater internal rotator strength in the dominant compared with the nondominant arm was evident with the HHD at the 90-90 position (11%, $P < .01$) and in the scapular plane (7%, $P < .05$). Using an HHD while performing manual muscle testing can quantify shoulder strength deficits that may not be apparent with isokinetic testing. By using an HHD during shoulder testing, clinicians can identify weakness that may have been presumed normal.
Neck muscle fatigue affects	*Neuroscience,* 2003;121(2):277-285.

postural control in man, Schieppati M, Nardone A, and Schmid M.	**Abstract:** We hypothesized that, since anomalous neck proprioceptive input can produce perturbing effects on posture, neck muscle fatigue could alter body balance control through a mechanism connected to fatigue-induced afferent inflow. Eighteen normal subjects underwent fatiguing contractions of head extensor muscles. Sway during quiet stance was recorded by a dynamometric platform, both prior to and after fatigue and recovery, with eyes open and eyes closed. After each trial, subjects were asked to rate their postural control. Fatigue was induced by having subjects stand upright and exert a force corresponding to about 35% of maximal voluntary effort against a device exerting a head-flexor torque. The first fatiguing period lasted 5 min (F1). After a 5-min recovery period (R1), a second period of fatiguing contraction (F2) and a second period of recovery (R2) followed. Surface EMG activity from dorsal neck muscles was recorded during the contractions and quiet stance trials. EMG median frequency progressively decreased and EMG amplitude progressively increased during fatiguing contractions, demonstrating that muscle fatigue occurred. After F1, subjects swayed to a larger extent compared with control conditions, recovering after R1. Similar findings were obtained after F2 and after R2. Although such behavior was detectable under both visual conditions, the effects of fatigue reached significance only without vision. Subjective scores of postural control diminished when sway increased, but diminished more, for equal body sway, after fatigue and recovery. Contractions of the same duration, but not inducing EMG signs of fatigue, had much less influence on body sway or subjective scoring. We argue that neck muscle fatigue affects mechanisms of postural control by producing abnormal sensory input to the CNS and a lasting sense of instability. Vision is able to overcome the disturbing effects connected with neck muscle fatigue.
Central motor excitability changes after spinal manipulation: A transcranial magnetic stimulation study, Dishman J, Ball K, Burke J.	*J Manipulative Physiol Ther* 2002;25:1-9 **Background:** The physiologic mechanism by which spinal manipulation may reduce pain and muscular spasm is not fully understood. One such mechanistic theory proposed is that spinal manipulation may intervene in the cycle of pain and spasm by affecting the resting excitability of the motoneuron pool in the spinal cord. Previous data from our laboratory indicate that spinal manipulation leads to attenuation of the excitability of the motor neuron pool when assessed by means of peripheral nerve Ia-afferent stimulation (Hoffmann reflex). **Objective:** The purpose of this study was to determine the effects of lumbar spinal manipulation on the excitability of the motor neuron pool as assessed by means of transcranial magnetic stimulation. **Methods:** Motor-evoked potentials were recorded subsequent to transcranial magnetic stimulation. The motor-evoked potential peak-to-peak amplitudes in the right gastrocnemius muscle of healthy volunteers (n = 24) were measured before and after homolateral L5-S1 spinal manipulation (experimental group) or side-posture positioning with no manipulative thrust applied (control group). Immediately after the group-specific procedure, and again at 5 and 10 minutes after the procedure, 10 motor-evoked potential responses were measured at a rate of 0.05 Hz. An optical tracking system (OptoTRAK, Northern Digital Inc, Waterloo, Canada [<0.10 mm root-mean-square]) was used to monitor the 3-dimensional (3-D) position and orientation of the transcranial magnetic stimulation coil, in real time, for each trial. **Results:** The amplitudes of the motor-evoked potentials were significantly facilitated from 20 to 60 seconds relative to the pre baseline value after L5-S1 spinal manipulation, without a concomitant change after the positioning (control) procedure. **Conclusions:** When motor neuron pool excitability is measured directly by central corticospinal activation with transcranial magnetic stimulation techniques, a transient but significant facilitation occurs as a consequence of spinal manipulation. Thus, a basic neurophysiologic response to spinal manipulation is central motor facilitation.
Assessment of isokinetic muscle strength in women who are obese,	*J Orthop Sports Phys Ther.* 2002 Jul;32(7):347-56.

Hulens M, Vansant G, Lysens R, Claessens AL, Muls E. -- Department of Rehabilitation Sciences, Faculty of Physical Education and Physiotherapy, Katholieke Universiteit, Leuven, Belgium. maria.hulens@flok.kuleuven.ac.be	**STUDY DESIGN:** Cross-sectional study of isokinetic trunk and knee muscle strength in women who are obese. **OBJECTIVE:** To provide reference values, to identify variables that affect peripheral muscle strength, and to provide recommendations for isokinetic testing of trunk and knee muscles in women who are obese and morbidly obese. **BACKGROUND:** The assessment of peripheral muscle strength is useful for the quantification of possible loss of strength, for exercise prescription, and for the evaluation of the effect of training programs in obese individuals. **METHODS AND MEASURES:** Isokinetic trunk and leg muscle strength was assessed in 241 women who were obese (18-65 years, body mass index (BMI) > or = 30 kg/m2). Trunk flexion and extension peak torque (PT) was measured using the Cybex TEF dynamometer; trunk rotation (TR) PT was measured using the Cybex TORSO dynamometer; and knee flexion/extension (KFE) PT was measured using the Cybex 350 dynamometer. Body composition was assessed using the bioelectrical impedance method; physical activity was assessed using the Baecke questionnaire; and peak VO2 was assessed using an incremental exercise capacity test on a bicycle ergometer. To identify variables related to muscle strength, Pearson correlations were computed and a stepwise multiple regression analysis was performed. **RESULTS:** Pearson correlation coefficients of all strength measurements at 60 degrees/s revealed low-to-moderate negative associations with age and positive associations with mass, height, fat free mass (FFM), and peak VO2 ($P < 0.05$), except for gravity-uncorrected trunk extension strength, which was not related to mass. The sports index of the Baecke questionnaire was associated with TR PT ($r = 0.20$, $P < 0.01$) and KFE PT ($r = 0.18$, $P < 0.05$). **CONCLUSION:** The weight of the trunk accounts largely for the measured trunk extensor and flexor strength in women who are obese. Contributing variables of isokinetic trunk flexion and extension strength in women who are obese are age, height, and FFM; whereas sports activities and aerobic fitness are contributing factors for trunk rotational and knee extension strength. Recommendations for measuring isokinetic muscle strength in individuals who are obese are provided.
Electromyographic reflex response to mechanical force, manually-assisted spinal manipulative therapy, Colloca, C.J., Keller, T.S.	*Spine*, 2001;26:1117-24 (http://www.journals.elsevierhealth.com/periodicals/ymmt/medline/record/MDLN.11413422) **Study Design:** Surface electromyographic reflex responses associated with mechanical force, manually assisted (MFMA) spinal manipulative therapy were analyzed in this prospective clinical investigation of 20 consecutive patients with low back pain. **Objectives:** To characterize and determine the magnitude of electromyographic reflex responses in human paraspinal muscles during high loading rate mechanical force, manually assisted spinal manipulative therapy of the thoracolumbar spine and sacroiliac joints. **Summary of Background Data:** Spinal manipulative therapy has been investigated for its effectiveness in the treatment of patients with low back pain, but its physiologic mechanisms are not well understood. Noteworthy is the fact that spinal manipulative therapy has been demonstrated to produce consistent reflex responses in the back musculature; however, no study has examined the extent of reflex responses in patients with low back pain. **Methods:** Twenty patients (10 male and 10 female, mean age 43.0 years) underwent standard physical examination on presentation to an outpatient chiropractic clinic. After repeated isometric trunk extension strength tests, short duration (<5 msec), localized posteroanterior manipulative thrusts were delivered to the sacroiliac joints, and L5, L4, L2, T12, and T8 spinous processes and transverse processes. Surface, linear-enveloped electromyographic (sEMG) recordings were obtained from electrodes located bilaterally over the L5 and L3 erector spinae musculature. Force-time and sEMG time histories were recorded simultaneously to quantify the association between spinal manipulative therapy mechanical and electromyographic response. A total of 1600 sEMG recordings were analyzed from 20 spinal manipulative therapy treatments, and comparisons were made between segmental level, segmental contact point (spinous vs. transverse

	processes), and magnitude of the reflex response (peak-peak [p-p] ratio and relative mean sEMG). Positive sEMG responses were defined as >2.5 p-p baseline sEMG output (>3.5% relative mean sEMG output). SEMG threshold was further assessed for correlation of patient self-reported pain and disability. **Results:** Consistent, but relatively localized, reflex responses occurred in response to the localized, brief duration MFMA thrusts delivered to the thoracolumbar spine and SI joints. The time to peak tension (sEMG magnitude) ranged from 50 to 200 msec, and the reflex response times ranged from 2 to 4 msec, the latter consistent with intraspinal conduction times. Overall, the 20 treatments produced systematic and significantly different L5 and L3 sEMG responses, particularly for thrusts delivered to the lumbosacral spine. Thrusts applied over the transverse processes produced more positive sEMG responses (25.4%) in comparison with thrusts applied over the spinous processes (20.6%). Left side thrusts and right side thrusts over the transverse processes elicited positive contralateral L5 and L3 sEMG responses. When the data were examined across both treatment level and electrode site (L5 or L3, L or R), 95% of patients showed positive sEMG response to MFMA thrusts. Patients with frequent to constant low back pain symptoms tended to have a more marked sEMG response in comparison with patients with occasional to intermittent low back pain. **Conclusions:** This is the first study demonstrating neuromuscular reflex responses associated with MFMA spinal manipulative therapy in patients with low back pain. Noteworthy was the finding that such mechanical stimulation of both the paraspinal musculature (transverse processes) and spinous processes produced consistent, generally localized sEMG responses. Identification of neuromuscular characteristics, together with a comprehensive assessment of patient clinical status, may provide for clarification of the significance of spinal manipulative therapy in eliciting putative conservative therapeutic benefits in patients with pain of musculoskeletal origin.
Sensory motor control of the lower back: implications for rehabilitation, Ebenbichler, G, Oddsson, L, Kollmitzer, J, Erim, Z.	*Med Sci Sports Exer,* 2001;33:1889-98 This paper described a series of studies that have been done investigating the surface electromyography (SEMG) fatigue pattern of the back muscles during submaximal contraction. SEMG changes correlated with erector muscle fatigue, validating the subjective erector muscle endurance tests against the objective SEMG. Given the results of this study, a larger double-blind study of SEMG evaluation compared to manual muscle testing could be done, wherein back muscles strength and endurance time during testing are measured before and after a course of chiropractic care.
Comparison of effects of spinal manipulation and massage on motoneuron excitability, Dishman J, Bulbulian R.	*Electromyogr Clin Neurophysiol.* 2001;41:97-106 **Abstract:** The purpose of this study was to compare the magnitude and duration of motoneuron inhibition occurring as a sequel to spinal manipulation or paraspinal and limb massage. The physiologic mechanisms involved in spinal manipulative therapy and massage therapy are largely unknown. One possible hypothesis is based upon the theory that these two distinct and different modalities may attenuate the activity of alpha motoneurons. Both modalities have been reported to produce short-term inhibition of motoneurons. Asymptomatic volunteers were randomly assigned to either a spinal manipulation, massage, or control group. Baseline tibial nerve H-reflex amplitudes were obtained prior to the application of either lumbosacral spinal manipulation or paralumbar and limb massage. Post-interventional H-reflex recordings were recorded immediately following the application of either modality. Spinal manipulation significantly ($p < 0.05$) attenuated alpha motoneuronal activity immediately post-therapy, as measured by the amplitude of the tibial nerve H-reflex. Massage subjects exhibited no significant reduction in motoneuronal activity immediately following administration. Spinal manipulation produced a transient attenuation of alpha motoneuronal excitability. Paraspinal and limb massage did not inhibit the motoneuron pool as measured immediately post-therapy. These findings support the supposition that spinal manipulation procedures lead to short-term inhibitory effects on motoneuron excitability to a greater magnitude than massage.

Conservative lower back treatment reduces inhibition in knee-extensor muscles: a randomized controlled trial, Suter, E., McMorland, G., Herzog, W., Bray, R.	*J Manipulative Physiol Ther*, 2000;23:76-80 (http://www.journals.elsevierhealth.com/periodicals/ymmt/article/PIIS016147540090071X/abstract) **Background:** Knee-joint pathologies, such as anterior knee pain (AKP), are associated with strength deficits and reduced activation of the knee extensors, which is referred to as *muscle inhibition* (MI). MI is thought to prevent full functional recovery, and treatment modalities that help to reduce or eliminate MI appear necessary for successful rehabilitation. Clinical observations suggest that AKP is typically associated with sacroiliac (SI) joint dysfunction. It is unknown whether Sl-joint dysfunction contributes to knee-extensor deficits and whether correction of SI-joint dysfunction alleviates MI. **Objective:** The objective of this study was to assess whether conservative low back treatment reduces lower limb MI. **Study design:** In a randomized, controlled, double-blind study the effects of conservative lower back treatment on knee-extensor strength and MI were evaluated in patients with AKP. **Methods:** Twenty-eight patients with AKP were randomly assigned to either a treatment or a control group. After a lower back functional assessment, the treatment group received a conservative treatment in the form of a chiropractic spinal manipulation aimed at correcting SI-joint dysfunction. The control group underwent a lower back functional assessment but received no joint manipulation. Before and after the manipulation or the lower back functional assessment, knee-extensor moments, MI, and muscle activation during full effort, isometric knee extensions were measured. **Results:** Patients showed substantial MI in both legs. Functional assessment revealed SI-joint dysfunction in all subjects (23 symptomatic and 5 asymptomatic). After the SI-joint manipulation, a significant decrease in MI of 7.5% was observed in the involved legs of the treatment group. MI did not change in the contralateral legs of the treatment group or the involved and contralateral legs of the control group. There were no statistically significant changes in knee-extensor moments and muscle activation in either group. **Conclusions:** The results of this study suggest that SI-joint manipulation reduces knee-extensor MI. Spinal manipulation may possibly be an effective treatment of MI in the lower limb musculature.
Abnormalities of the soleus H-reflex in lumbar spondylolisthesis: a possible early sign of bilateral S1 root dysfunction, Mazzocchio R, Scarfo GB, Cartolari R, Bolognini A, Mariottini A, Muzii VF, Palma L.	*J Spinal Disord.* 2000 Dec;13(6):487-95. **Abstract:** Using routine electrodiagnostic procedures, the authors searched for physiologic evidence of nerve root compromise in patients with chronic mechanical perturbation to the lumbar spine. They examined 37 patients with spondylolisthesis and various degrees of degenerative changes in the lumbar canal. Clinical and neurophysiologic findings were compared with data obtained from 36 healthy persons. The soleus H-reflex appeared to be a sensitive indicator of sensory fiber compromise at the S1 root level, because changes correlated well with the focal sensory signs and preceded clinical and electromyographic signs of motor root involvement. When these occurred, the clinical findings were consistent with a more severe nerve root deficit and with radiographic evidence of neural compression. The greater sensitivity of the soleus H-reflex may be related to the pathophysiologic events that occur at the lesion site.
Integrated jaw and neck function in man. Studies of mandibular and head-neck movements during jaw opening-closing tasks, Zafar H	*Swed Dent J Suppl*, 2000;(143):1-41. **Abstract:** This investigation was undertaken to test the hypothesis of a functional relationship between the human temporomandibular and craniocervical regions. Mandibular and head-neck movements were simultaneously recorded in healthy young adults using a wireless optoelectronic system for three dimensional movement recording. The subjects were seated in an upright position without head support and were instructed to perform maximal jaw opening-closing movements at fast and slow speed. As a basis, a study was undertaken to develop a method for recording and analysis of mandibular and head-neck

	movements during natural jaw function. A consistent finding was parallel and coordinated head-neck movements during both fast and slow jaw opening-closing movements. The head in general started to move simultaneously with or before the mandible at the initiation of jaw opening. Most often, the head attained maximum velocity after the mandible. A high degree of spatiotemporal consistency of mandibular and head-neck movement trajectories was found in successive recording sessions. The head movement amplitude and the temporal coordination between mandibular and head-neck movements were speed related but not the movement trajectory patterns. Examination of individuals suffering from temporomandibular disorders and whiplash associated disorders (WAD) showed, compared with healthy subjects, smaller amplitudes, a diverse pattern of temporal coordination but a similar high degree of spatiotemporal consistency for mandibular and head-neck movements. In conclusion, the results suggest the following: A functional linkage exists between the human temporomandibular and craniocervical regions. Head movements are an integral part of natural jaw opening-closing. "Functional jaw movements" comprise concomitant mandibular and head-neck movements which involve the temporomandibular, the atlanto-occipital and the cervical spine joints, caused by jointly activated jaw and neck muscles. Jaw and neck muscle actions are elicited and synchronized by neural commands in common for both the jaw and the neck motor systems. These commands are preprogrammed, particularly at fast speed. In the light of previous observations of concurrent jaw and head movements during foetal yawning, it is suggested that these motor programs are innate. Neural processes underlying integrated jaw and neck function are invariant both in short- and long-term perspectives. Integrated jaw and neck function seems to be crucial for maintaining optimal orientation of the gape in natural jaw function. Injury to the head-neck, leading to WAD may derange integrated jaw-neck motor control and compromise natural jaw function. **Comment:** In AK examination and treatment, the complexity of the TMJ apparatus is recognized. The TMJ is part of a complex system including the bones of the skull and cervical spine, the mandible and hyoid bone, the related muscle attachments and other soft tissues, and neurologic and vascular components. This complex is often referred to as the stomatognathic system. The use of AK methods, especially challenge and therapy localization, greatly assists the practitioner in finding concealed or hidden TMJ problems.
EMG and strength correlates of selected shoulder muscles during rotations of the glenohumeral joint, David G, Magarey ME, Jones MA, Dvir Z, Turker KS, Sharpe M.	*Clin Biomech (Bristol, Avon).* 2000 Feb;15(2):95-102. **OBJECTIVE:** To identify activation patterns of several muscles acting on the shoulder joint during isokinetic internal and external rotation. **DESIGN:** Combined EMG and isokinetic strength analysis in healthy subjects. **BACKGROUND:** EMG studies of the shoulder region revealed intricate muscular activation patterns during elevation of the arm but no parallel studies regarding pure rotations of the joint could be located. **METHODS:** Fifteen (n=30 shoulders) young, asymptomatic male subjects participated in the study. Strength production during isokinetic concentric and eccentric internal and external rotations at 60 and 180 degrees /s was correlated with the EMG activity of the rotator cuff, biceps, deltoid and pectoralis major. Analysis of the smoothed EMG related to the timing of onset of the signal and to the normalized activity at the angle of the peak moment. Determination of the association between the EMG and the moment was based on strength ratios. **RESULTS:** Findings indicated that for both types of rotations, the rotator cuff and biceps were active 0.092+/-0.038-0.215+/-0.045 s prior to the initiation of the actual movement and 0.112-0.034 s prior to onset of deltoid and pectoralis major activity. These differences were significant in all of the eight conditions ($P<0.05$). In terms of the strength ratios, strong association was found between electrical activity and moment production in the subscapularis and infraspinatus ($r(2)=0.95$ and 0. 72, respectively) at the low and high angular velocities. **CONCLUSIONS:** Prior to actual rotation of the shoulder joint, normal recruitment of the rotator cuff and biceps is characterized by a non-specific presetting phase which is mainly directed at enhancing the joint 'stiffness' and hence its stability. Once movement is in progress, the EMG patterns of these muscles become movement specific

	and are correlated with the resultant moment. **RELEVANCE:** Muscular dysfunction relating to delayed onset activity or altered activation patterns, due to pain, perturbed mechanics or disturbed neural activation have been implicated as concomitant factors in other joint associated pathologies. Through highlighting the role of the rotator cuff in shoulder joint rotations, this study lends further support to the argument that a parallel situation may prevail with respect to shoulder joint dysfunction. This could lead to the development of rehabilitation protocols aimed specifically at redressing such dysfunction.
Decrease in quadriceps inhibition after sacroiliac joint manipulation in patients with anterior knee pain, Suter, E., McMorland, G., Herzog, W., Bray, R.	*J Manipulative Physiol Ther*, 1999;22:149-153 (http://www.journals.elsevierhealth.com/periodicals/ymmt/article/PIIS0161475499701284/abstract) **Background:** Evidence exists that conservative rehabilitation protocols fail to achieve full recovery of muscle strength and function after joint injuries. The lack of success has been attributed to the high amount of muscle inhibition found in patients with pathologic conditions of the knee joint. Clinical evaluation shows that anterior knee pain is typically associated with sacroiliac joint dysfunction, which may contribute to the muscle inhibition observed in this patient group. **Objective:** To assess whether sacroiliac joint manipulation alters muscle inhibition and strength of the knee extensor muscles in patients with anterior knee pain. **Design and Setting:** The effects of sacroiliac joint manipulation were evaluated in patients with anterior knee pain. The manipulation consisted of a high-velocity low-amplitude thrust in the side-lying position aimed at correcting sacroiliac joint dysfunction. Before and after the manipulation, torque, muscle inhibition, and muscle activation for the knee extensor muscles were measured during isometric contractions using a Cybex dynamometer, muscle stimulation, and electromyography, respectively. **Participants:** Eighteen patients (mean age, 30.5 ± 13.0 years) with either unilateral (n = 14) or bilateral (n = 4) anterior knee pain. **Results:** Patients showed substantial muscle inhibition in the involved and the contralateral legs as estimated by the interpolated twitch technique. After the manipulation, a decrease in muscle inhibition and increases in knee extensor torques and muscle activation were observed, particularly in the involved leg. In patients with bilateral anterior knee pain, muscle inhibition was decreased in both legs after sacroiliac joint adjustment. **Conclusions:** Spinal manipulation might offer an interesting alternative treatment for patients with anterior knee pain and muscle inhibition. Because this clinical outcome study was of descriptive nature rather than a controlled design, biases might have occurred. Thus the results have to be verified in a randomized, controlled, double-blinded trial before firm conclusions can be drawn or recommendations can be made.
Sacroiliac joint involvement in activation of the porcine spinal and gluteal musculature, Indahl, A., Kaigle, A., Reikeras, O., Holm, S.H. (Here in MMT Paper transfer)	*J Spinal Disord*, 1999;12:325-30 Abstract: This experiment involved stimulation of the sacroiliac joint that was found to cause neuromuscular responses in the gluteus maximus, quadratus lumborum, and multifidus muscles. This muscular activation was found to assist in the control of locomotion and body posture and to provide stability to the sacroiliac joint and lumbar spine. Thus, sensitization of sacroiliac joint nociceptive afferents were suggested to not only contribute to mechanical low back pain, but plays a role also in sacroiliac joint biomechanics via reflexogenic activation of the trunk and gluteal muscles. Comment: Given the results of this study, a larger double-blind study evaluating sacroiliac joint biomechanics in relationship applied kinesiology diagnostic procedures for the sacroiliac joint could be done, wherein back muscles strength tests are measured before and after a course of chiropractic care for the sacroiliac joints.
Sensorimotor control of the spine, Holm, S., Indahl, A., Solomonow,	*Journal of Electromyography and Kinesiology*, 12;3:219-234.

M.	(http://www.isek-online.org/) **Abstract:** The spinal viscoelastic structures including disk, capsule and ligaments were reviewed with special focus on their sensory motor functions. Afferent capable of monitoring proprioceptive and kinesthetic information are abundant in the disc, capsule and ligament. Electrical stimulation of the lumbar afferents in the discs, capsules and ligaments seem to elicit reflex contraction of the multifidus and also longissimus muscles. The muscular excitation is pronounced in the level of excitation and with weaker radiation 1 to 2 levels above and below. Similarly, mechanical stimulation of the spinal viscoelastic tissues excites the muscles with higher excitation intensity when more than one tissue (ligaments and discs for example) is stimulated. Overall, it seems that spinal structures are well suited to monitor sensory information as well as to control spinal muscles and probably also provide kinesthetic perception to the sensory cortex.
Reduced muscle function in patients with osteoarthritis, Fisher NM, Pendergast DR. -- Department of Rehabilitation Medicine, State University of New York at Buffalo, USA.	*Scand J Rehabil Med*.1997 Dec;29(4):213-21 **Abstract:** The purpose of this study was to determine whether subjects with knee osteoarthritis (OA) had reduced muscle strength at various muscle lengths, endurance, contraction velocity and functional capacity, compared with control subjects and whether the decrease was related to functional capacity. Forty-five men and 45 women with knee OA were compared with a control group (41 males, 63 females) of similar age for functional capacity, maximal isometric strength (in vivo length-tension relationship) and endurance (in vivo force-time relationship) of knee flexion and extension and maximal angular velocity (in vivo force-velocity relationship) of knee extension. The OA subjects had increased difficulty (2.03 +/- 0.53) and pain (1.65 +/- 0.29) for activities of daily living (ADLs) and significantly lower strength for extension (72%) and flexion (56%), endurance for the quadriceps (203%) and hamstrings (214%) and velocity (128%). The reductions were greater at longer muscle lengths. These data demonstrate that patients with knee OA have reduced muscle function and functional capacity compared to controls.
Muscle function and gait in patients with knee osteoarthritis before and after muscle rehabilitation, Fisher NM, White SC, Smolinski RJ, Pendergast DR.	*Disabil and Rehabil.*1997 Feb;19(2):47-55 **Abstract:** Patients with knee osteoarthritis (OA) have reduced functional capacity and muscle function that improves significantly after quantitative progressive exercise rehabilitation (QPER). The effects of these changes on the biomechanics of walking have not been quantified. Our goal was to quantify the effects of knee OA on gait before and after QPER. Bilateral kinematic and kinetic analyses were performed using a standard link-segment analysis on seven women (60.9 +/- 9.4 years) with knee OA. All functional capacity, muscle function and gait variables were initially reduced compared to age-matched controls. Muscle strength, endurance and contraction speed were significantly improved (55%, 42% and 34%, respectively) after 2 months of QPER ($p < 0.05$), as were function (13%), walking time (21%), difficulty (33%) and pain (13%). There were no significant changes in the gait variables after QPER. To use the QPER improvements to the best advantage, gait retraining may be necessary to "re-programme' the locomotor pattern.
Spinal manipulation results in immediate H-reflex changes in patients with unilateral disc herniations, Floman Y, Liram N, Gilai AN.	*Eur Spine J.* 1997;6(6):398-401. **Abstract:** The aim of this clinical investigation was to determine whether the abnormal H-reflex complex present in patients with S1 nerve root compression due to lumbosacral disc herniation is improved by single-session lumbar manipulation. Twenty-four patients with unilateral disc herniation at the L5-S1 level underwent spinal H-reflex electro-physiological evaluation. This was carried out before and after single-session lumbar manipulation in the side-lying position. Eligibility criteria for inclusion in the study were: predominant sciatica, no motor or sphincteric involvement, unilateral disc herniation at the L5-S1 level on CT or MR imaging, age between 20 and 50 years. H-reflex responses were recorded bilaterally

	from the gastrosoleus muscle following stimulation of tibial sensory fibers in the popliteal fossa. H-reflex amplitude in millivolts (HR-A) and H-reflex latency in milliseconds (HR-L) were measured from the spinal reflex response. Pre- and post-manipulation measurements were compared between the affected side and the healthy side. Statistical evaluation was performed by the Wilcoxon matched-pairs test (SPSS). Thirteen patients displayed abnormal H-reflex parameters prior to lumbar manipulation, indicating an S1 nerve root lesion. The mean amplitude was found to be significantly lower on the side of disc herniation than on the normal, healthy side (P = 0.0037). Following manipulation, the abnormal HR-A increased significantly on the affected side while the normal HR-A on the healthy side remained unchanged (P = 0.0045). There was a significant difference between latencies on the affected side and those on the healthy side (P = 0.003). Following manipulation there was a trend toward decreased HR-L. However, this trend did not reach statistical significance (P = 0.3877). Eight patients displayed no H-reflex abnormalities before or after manipulation. Their respective HR-A and HR-L values did not change significantly following manipulation. Three additional patients were excluded due to technical difficulties in achieving manipulation or measuring spinal reflex. These observations may lend physiological support for the clinical effects of manipulative therapy in patients with degenerative disc disease.
The manual muscle examination for rotator cuff strength. An electromyographic investigation, Kelly BT, Kadrmas WR, Speer KP.	*Am J Sports Med.* 1996 Sep-Oct;24(5):581-8. **Abstract:** The electromyographic activity of eight muscles of the rotator cuff and shoulder girdle (supraspinatus, infraspinatus, subscapularis, pectoralis, latissimus dorsi, and the anterior, middle, and posterior deltoid) was measured from the nondominant shoulders of 11 subjects during a series of 29 isometric contractions. The contractions simulated different positions used for strength testing of the rotator cuff and involved elevation, external rotation, and internal rotation at three degrees of initial humeral rotation (-45 degrees of internal rotation, 0 degree, +45 degrees of external rotation) and scapular elevation (0 degree, 45 degrees, 90 degrees). Isolation of the supraspinatus muscle was best achieved with the test position of elevation at 90 degrees of scapular elevation and +45 degrees (external rotation) of humeral rotation. Isolation of the infraspinatus muscle was best achieved with external rotation at 0 degree of scapular elevation and -45 degrees (internal rotation) of humeral rotation. Isolation of the subscapularis muscle was best achieved with the Gerber push-off test. This study used four criteria for identifying the optimal manual muscle test for each rotator cuff muscle: 1) maximal activation of the cuff muscle, 2) minimal contribution from involved shoulder synergists, 3) minimal provocation of pain, and 4) good test-retest reliability. Based on the results of this study and known painful arcs of motion, an objective identification of the optimal tests for the manual muscle testing of the cuff was elucidated.
Disturbed eye movements after whiplash due to injuries to the posture control system, Gimse R, Tjell C, Bjorgen IA, Saunte C.	*J Clin Exp Neurophychol*, 1996;18(2):178-86. **Abstract:** Self-reports after whiplash often indicate associations with vertigo and reading problems. Neuropsychological and otoneurological tests were applied to a group of whiplash patients (n = 26) and to a carefully matched control group. The whiplash group deviated from the control group on measures of eye movements during reading, on smooth pursuit eye movements with the head in normal position, and with the body turned to the left or to the right. Clinical, caloric, and neurophysiological tests showed no injury to the vestibular system or to the CNS. Test results suggest that injuries to the neck due to whiplash can cause distortion of the posture control system as a result of disorganized neck proprioceptive activity. **Comment:** Central to the concept of applied kinesiology chiropractic evaluation and treatment is the consideration that the senses of seeing, hearing, smelling, tasting, feeling, and balance are not simple, specific sensations; rather they are sensory systems closely interrelated among themselves and intimately linked with motor functions. In applied

	kinesiology chiropractic methodology, a means for testing the integration of the muscles in the body with the visual reflexes has been termed *ocular lock*. It demonstrates the failure of the eyes to work together on a binocular basis through the cardinal fields of gaze. This is usually not gross pathology of cranial nerves III, IV, and VI; rather it is poor functional organization. Mechanical irritation of cranial nerves III, IV, or VI (usually VI) may be responsible for disturbed binocular function leading to discordant sensory inputs from the visual righting reflex. When the eyes are turned in a specific direction, a previously strong indicator muscle will weaken when the ocular lock test is positive, and there is probably disturbance in the visual righting, vestibulo-ocular, or opto-kinetic reflexes.
Sacroiliac joint manipulation decreases the H-reflex, Murphy, B.A., Dawson, N.J., Slack, J.R.	*Electromyogr Clin Neurophysiol*, 1995;35:87-94 **Abstract:** Joint manipulation is widely utilized clinically to decrease pain and increase the range of motion of joints displaying limited mobility. Evidence of efficacy is based on subjective reports of symptom improvement as well as on the results of clinical trials. Experiments were designed to determine whether or not sacroiliac joint manipulation affects the amplitude of the Hoffman (H) reflex. Surface EMG recordings of the reflex response to electrical stimulation of the tibial nerve in the popliteal fossa were made from the soleus muscle. The averaged amplitudes of H-reflexes were compared on both legs before and after either sacroiliac joint manipulation or a sham procedure. H-reflex amplitude was significantly decreased (12.9%) in the ipsilateral leg ($p < 0.001$) following a sacroiliac joint manipulation while there was no significant alteration following the sham intervention. There was no significant alteration in reflex excitability in the contralateral leg to the sacroiliac joint manipulation. To further investigate the mechanism of these reflex alterations, the local anesthetic cream EMLA (Astra Pharmaceuticals) was applied to the skin overlying the sacroiliac joint and the experiments were repeated on a different group of subjects. This was intended to determine if excitation of cutaneous afferents was responsible for the reflex excitability changes. There was still a significant decrease in reflex excitability (10.6%) following sacroiliac joint manipulation ($p < 0.001$). These findings indicate that joint manipulation exerts physiological effects on the central nervous system, probably at the segmental level. The fact that the changes persisted in the presence of cutaneous anesthesia suggests that the reflex changes are likely to be mediated by joint and/or muscle afferents.
The role of sensory information in the guidance of voluntary movement, McCloskey, D.I., Prochazka, A.	*Somatosensory and Motor Research*, 1994;11:69-76 **Abstract:** For voluntary movements to be well timed and accurate, they require coordinated tactile, visual and proprioceptive information about the movement in progress. Locomotion should be a stable cycle generated by the sensory links between the musculoskeletal system, the neural system and the environment.
Neuromuscular effects of temporomandibular joint dysfunction, Esposito, V., Leisman, G., Frankenthal, Y.	*Intern J Neuroscience*, 1993;68 **Abstract:** Neurologically intact male and female TMJ dysfunction patients with or without cervical spine involvement were examined using standard clinical neurologic testing for balance and coordination. Seventy percent of the TMJ patients without cervical involvement exhibited positive signs for balance, coordination, and/or ataxia found in response to having the patient's mandible stressed by extending it a far as possible laterally, and also opened (as wide as possible) or closed (biting down). The performance of patients with cervical involvement was not significantly different than those without cervical involvement. Further examination of the relation between the TMJ and auditory, visual, cerebellar, and coordination mechanisms is therefore indicated.
Postural control in young and elderly adults when stance is	*Journal of Gerontology*, 1992; 47:M79-M87. **Abstract:** Increased postural sway and falling are associated with aging and are likely

perturbed: kinematics, Alexander, N. B, Shepard, N, Gu, MJ, Schultz, A.	related to problems with postural control in the elderly. We investigated the motions of individual body segments in 24 healthy young adults and 15 healthy elderly adults (mean ages 26 and 72) in response to four tasks: (a) standing with feet flat on an anteriorly accelerating platform (Flat Translation); standing on a narrow beam support that was (b) stationary (Beam Standing) and (c) accelerating anteriorly (Beam Translation); and (d) standing on a rotatable but otherwise stationary springboard (Springboard Standing). An optoelectronic camera system was used to measure rotations of body segments, particularly regarding their maximum excursions, time to first rotation response, direction of initial rotation, and time to first rotation reversal. In general, larger rotation excursions were noted in the elderly compared to the young group, particularly in the Beam Standing and Beam Translation tasks, but the magnitude of rotation difference was small. All rotation magnitudes were well within the available ranges of motion of the body joints. In both excursion magnitudes and directions of initial rotation, the elderly showed greater variability than the young. In the Beam Translation task, the elderly group, compared to the young, tended to rotate their upper body segments more than in the Flat Translation task. These data suggest that healthy elderly adults with no apparent musculoskeletal or neurological impairments have small but consistent differences in postural control kinematics, particularly when more challenging conditions are presented. Moreover, these data provide the basis for biomechanical analyses of joint torques and other dynamic requirements of these responses. **Comment:** Manual muscle testing is the method of testing functional neurology and postural mechanisms in applied kinesiology. Normally there is predictable facilitation and inhibition of muscle function. When there is not, applied kinesiology testing methods are employed to discover and correct the factors responsible for the disturbance in predictable muscle function. The importance of restoring normal function in elderly patients is demonstrated by the postural kinematic disturbances of the patients in this study.
The pain-adaptation model: a discussion of the relationship between chronic musculoskeletal pain and motor activity, Lund, J.P., et al.	*Canadian Journal of Physiology and Pharmacology*, 1991;69:683-694. **Abstract:** Articles describing motor function in five chronic musculoskeletal pain conditions (temporomandibular disorders, muscle tension headache, fibromyalgia, chronic lower back pain, and postexercise muscle soreness) were reviewed. It was concluded that the data do not support the commonly held view that the pain of these conditions is maintained by some form of tonic muscular hyperactivity. Instead, it seems clear that in these conditions the activity of agonist muscles is often reduced by pain, even when this does not arise from the muscle itself. On the other hand, pain causes small increases in the level of activity of the antagonist. As a consequence of these changes, force production and the range and velocity of movement of the affected body part are often reduced. To explain how such changes in the behavior come about, we propose a neurophysiological model based on the phasic modulation of excitatory and inhibitory interneurons supplied by high-threshold sensory afferents. We suggest that the "dysfunction" that is characteristic of several types of chronic musculoskeletal pain is a normal protective adaptation and is not a cause of pain. **Comment:** This paper articulates with fascinating similarity one of the major hypotheses in AK, namely that physical, chemical, or emotional imbalances produce secondary muscle dysfunction, specifically a muscle inhibition (usually followed by overfacilitation of an opposing muscle). Muscles lose function and become inhibited because of structural problems like trauma or chemical imbalance due to a hormonal influence or mental/emotional stress.
Limb Segment Information Transmission Capacity Infers Integrity of Spinothalamic Tracts and Cortical Visual-Motor Control, Leisman, G., Vitori, R.	*International Journal of Neuroscience*. 1990; 50:175-183. **Abstract:** Limb segment movement times have been investigated previously in relation to Fitts' Index of Difficulty ($ID = \log_2 2A/W$) over various movement distances. Results supported Fitts' theory that different limb segments show different maximum information

	processing rates. The results indicated that visually-mediated discrete correction control processes are used. In the presently reported experiments, normal human subjects performed movements with left or right arms. Visual-motor control was inter- or intrahemispheric. Direction of movement was adductive or abductive. It was hypothesized that abductive movements are controlled by the contralateral hemisphere while adductive movements are controlled by either hemisphere. It was also hypothesized that abductive movements are related to the lateral system which projects to the contralateral side of the spinal cord. The control of adductive movements is related to the medial system which projects bilaterally to the spinal cord.
Changes in Electrical Activity in Muscles Resulting from Chiropractic Adjustment: A Pilot Study, Shambaugh P.	*J Manipulative Physiol Ther* 1987;10(6):300-304 This study examines the effects of chiropractic adjustment on the muscles of the back. Vertebrae that are hypomobile may be held in that state by the erector spinae muscle group; adjusting such vertebrae should result in les muscle tension. By measuring the change in electrical activity, such relaxation can be observed. Hypomobile vertebrae were found by motion palpation. The patient was then placed prone and surface electrodes were placed over the upper trapezius, upper erector spinae (T3-T5), and lumbar erector spinae (L1-L3) muscle groups on both sides of the body. The patient was adjusted using full spine toggle recoil thrusts, and postadjustment readings were taken. Results from this study show that significant changes in muscle electrical activity occur as a consequence of adjusting. On average, a 25% reduction in muscle activity was observed across the 20 subjects tested, while no significant reductions were observed with the control group of 14 subjects. Significant reductions in side-to-side imbalances were also observed.
The relationship of injuries of the leg, foot, and ankle to proximal thigh strength in athletes, Nicholas JA, Marino M.	*Foot Ankle.* 1987 Feb;7(4):218-28 **Abstract:** Rehabilitation programs designed to restore leg, ankle, and foot function following injury frequently ignore the proximal muscles. During athletics, these knee, hip, and trunk muscles derive much of their functional power from the foot and ankle. They also serve to integrate distal segment motions into a total movement pattern such as jumping, running, or kicking. The linkage system, which is a theoretical concept, describes the normal biomechanical and physiological interactions between proximal and distal musculoskeletal structures. Immobilization or injury of distal segments interrupts the normal generation, summation, and transmission of muscular forces across joints. Adequate measures must be taken to properly assess proximal structures for weakness and tightness and to prescribe specific exercises to prevent the migration of the effects of injury away from the involved segment. **Comment:** In AK examination and treatment, the “linkage system” is appreciated. The leg, foot, and ankle are part of a complex system that links the foot and leg and their related muscle attachments and other soft tissues, and neurologic and vascular components, to the rest of the neuromusculoskeletal system The use of AK methods, especially challenge and therapy localization, greatly assists the practitioner in finding concealed or hidden linkages between problems in the foot and leg and other muscular problems throughout the body.
Finger flexion function in rheumatoid arthritis: the reliability of eight simple tests, Armstrong R, Horrocks A, Rickman S, Heinrich I, Kay A, Gibson T.	*Br J Rheumatol* 1987;26:118-122. The inter- and intra-observer errors of eight tests of finger flexion function were estimated from the results obtained by three observers assessing 10 patients with rheumatoid hand involvement. Measurements of finger flexion and muscle power involved both conventional and novel techniques using simple and easily constructed apparatus. For each test, measurements were in agreement between observers and were reproducible on three occasions. These tests may now be used with confidence by other investigators.
Functional assessment of the hand: reproducibility,	*Ann Rheum Dis* 1987;46:203-208

acceptability, and utility of a new system for measuring strength, Helliwell P, Howe A, Wright V.	A new system for measuring strength of the hand using a torsion dynamometer linked to a microprocessor is described. The system permits analysis of timed squeezes of both grip and pinch and is adjustable to all sizes of hand and degrees of hand deformity. Results obtained with the system were found to be reproducible, and the rigid device was acceptable to a group of patients with arthritic hands. In rheumatoid arthritis, there is a marked reduction in maximum grip and pinch strength, together with a prolongation of the time taken to reach this maximum, and increased fatigue. The limitations of grip strength as a measure of function of the hand are discussed.
Clinical and electromyographical course of sciatica: prognostic study of 41 cases, Negrin P, Fardin P.	*Electromyogr Clin Neurophysiol* 1987;27:125-127 **Abstract:** The study of the clinical and EMGraphical course of patients with sciatica may help us to decide between a simple symptomatic treatment and an admission to hospital for neuroradiological tests and possible surgery. 41 patients with acute lumbosciatalgia and EMGraphically proven monoradicular denervation were studied: the root affected was L5 in 39 cases (78%), L4 in 7 cases and S1 in 2 cases. 19 of these cases were then submitted to surgical treatment of disc protrusion removal, the other 22 were treated medically. 3 to 8 years later, the following parameters were tested: pain, motor impairment, EMG denervation and degree of patient's subjective judgment. We concluded that urgent hospital admission is indicated only in the case of severe and/or recent (within 1 month) paralysis or in the case of intolerable painful symptomatology. The diagnostic and prognostic role of EMG is hence confirmed: this examination yields information on the identity of the root involved, the severity of the denervation, its course and the degree of final improvement expected.
The relationship of knee and ankle weakness to falls in nursing home residents, Whipple, R, Wolfson, L, Amerman, P.	*J Am Geriatr Soc,* 1987;35:329-32 A study of nursing home residents with a history of falling found that muscle force and isokinetic power were significantly decreased in knee flexors (quadriceps) and extensors (hamstrings), and ankle dorsiflexors (tibialis anterior) and plantar flexors (gastrocnemius and soleus). Dorsiflexors were particularly weak in fallers, suggesting that they are an important factor contributing to balance. Of particular interest was ankle flexor and extensor strength because these muscles are linked to balance impairment in older adults with a history of falling. Strength training and other treatments that may improve muscle function in these areas may enhance balance in balance-impaired older adults.
Correlation of objective measure of trunk motion and muscle function with low-back disability ratings, Triano, J, Schultz, A	*Spine,* 1987;12:561-5 **Abstract:** A study was undertaken to examine relations among some objective and subjective measures of low-back-related disability in a group of 41 low-back pain patients and in seven pain-free control subjects. Subjective measures of disability were obtained by Oswestry patient questionnaires. Oswestry disability score related significantly (P less than 0.001) to presence or absence of relaxation in back muscles during flexion. Mean trunk strength ratios were inversely related to disability score (P less than .05), and trunk mobility was meaningfully reduced (P less than .01). Despite loss of motion, a large enough excursion was observed to predict presence of back muscle relaxation. These findings imply that myoelectric signal levels, trunk strength ratios, and ranges of trunk motion may be used as objective indicators of low-back pain disability. **Comment:** The findings in this study imply that muscle function, as measured by EMG, MMT, and ranges of trunk motion may be used as objective indicators of low-back pain disability.
Contractile changes in opposing muscles of the human ankle join with aging, Vandervoort, A,	*J Appl Physiol,* 1986;61:361-7 This article demonstrates that strength declines approximately 15% per decade between the ages of 50 and 70 years, and approximately 1.5% per year after the age of 70 years, and

McComas, A.	decreases in strength are associated with falling in elderly people.
Physical measurements as risk indicators for low back trouble over a one year period, Biering-Sorensen, F.	*Spine,* 1984;9:106-19 This paper assessed the endurance of the erector spinae muscles. It was found that subjects with poorer isometric endurance in this trunk muscle had a greater likelihood of developing low back trouble in the future.
Musculoskeletal performance testing and profiling of elite competitive fencers, Sapega AA, Minkoff J, Valsamis M, Nicholas JA.	*Clin Sports Med.* 1984 Jan;3(1):231-44. **Abstract:** Twenty-four male members of the 1976 United States Olympic Fencing Squad were profiled. **Data were collected on anthropometry; flexibility; and muscular strength, endurance, and power. Five of the physical variables measured in the laboratory were shown to have a significant relationship to competitive success.**
Usefulness of electrophysiological studies in the diagnosis of lumbosacral root disease, Tonzola R, Ackil A, Shahani B, Young R.	*Ann Neurol* 1981;9:305-308 **Abstract:** Clinical, electrophysiological, and myelographic findings were correlated in 57 patients with the clinical diagnosis of lumbosacral root disease. Conventional motor and sensory (including sural nerve) conduction studies were normal in all patients. Electromyography, late response studies in different muscles of the lower extremity, the myelogram, or combinations of these tests were abnormal in 44 patients (77%). Of 36 patients (63%) with abnormal myelograms, 14 had normal electrophysiological studies. Twenty-nine (51%) had an abnormal electrophysiological or myelographic finding; although 8 patients in this group had a normal myelogram, 2 had an abnormal discogram and 1 an abnormal epidurogram. Electrophysiological or myelographic findings, in some cases both, correlated well with clinical signs and symptoms in 41 patients (72%). H-reflex and F response studies, when abnormal, helped in localizing a lesion in the appropriate root distribution. **Comment:** This study demonstrates that EMG shows better correlation with neurological examinations than CT scans or myelograms for nerve root disturbances in the lumbosacral spine. In other words, muscle dysfunction correlates better with lumbosacral nerve root injuries than CT scans or myelograms.
Trunk strengths in attempted flexion, extension, and lateral bending in healthy subjects and patients with low-back disorders, McNeill T, Warwick D, Andersson G, Schultz A.	*Spine.* 1980 Nov-Dec;5(6):529-38. **Abstract:** Trunk strengths were measured in 27 healthy males and 30 health females, and in 25 male and 15 female patients with low-back pain and/or sciatica. Maximum voluntary isometric strengths were measured during attempted flexion, extension, and lateral bending from an upright standing position. Both male and female patients had approximately 60% of the absolute trunk strengths of the corresponding healthy subjects. Intra-individual trunk strength ratios were used to interpret the results. Use of these ratios tends to avoid interpretational problems created by the general weakness of the patients and any lack of motivation of either patients or healthy subjects. The ratios showed that the patients had attempted extension strengths that were significantly less than their strengths in the other types of movements tested. The strength ratios for attempted extension were particularly low for patients with sciatica.
Trunk strengths in patients seeking hospitalization for chronic low-back disorders, Addison R, Schultz A.	*Spine.* 1980 Nov-Dec;5(6):539-44. **Abstract:** Trunk strengths of 16 male and 17 female patients with chronic low-back disorders were measured. The patients sought hospitalization for four weeks in a pain clinic. Maximum voluntary trunk strengths in the standing position were measured during attempted flexion, extension, and lateral bending. The trunk strengths of these patients were then compared with those of health subjects and with those of patients with low-back

	disorders who sought treatment as outpatients of a general orthopaedic office practice. In making the comparisons, intra-individual trunk-strength ratios were used to overcome problems due to the effects of patients' general weakness and any psychologic factors. **When compared with healthy subjects, the patients seeking hospitalization had significantly smaller strengths during attempted extension relative to their strengths during attempted flexion or lateral bending.** Their trunk-strength ratios did not differ significantly from those of the outpatient group.
Back and leg complaints in relation to muscle strength in young men, Karvonen MJ, Viitasalo JT, Komi PV, Nummi J, Jarvinen T.	*Scand J Rehabil Med.* 1980;12(2):53-9. **Abstract:** Back and leg complaints were studied by using a questionnaire and medical examination in 183 male conscripts and relating the results to background variables, anthropometry, the isometric strength of large muscle groups, and endurance running. A history of sciatica was reported by 8%, lumbago by 13%, back injury by 13% and low back insufficiency by 63%. Weak trunk extensors were associated with a history of sciatica, weak trunk flexors with back injuries and with current backache at work/exercise. Weak leg extensors showed associations with a history of low back insufficiency and of sick leave due to the back and with current hip pain. Men with a history of lumbago and of hip and knee complaints performed poorly during 12 min of running. Back and leg complaints were more frequent in men with high socio-economic status, who engaged in little physical activity, or who were obese. The questionnaire and strength measurements proved suitable for studying low back syndrome in its early stages.
An Experimental Evaluation of Kinesiology in Allergy and Deficiency Disease Diagnosis, Scopp, A.	*Journal of Orthomolecular Psychiatry*. 1979; 7(2):137-8. **Abstract:** An accurate, reliable, and quick method for determining vitamin-mineral imbalances and food allergies is critical in establishing a balanced behavioral biochemistry. Dr. George Goodheart has clinically observed that whenever a patient was deficient in a specific vitamin or food factor, a specific muscle which he found to be associated with the nutrient was almost always unilaterally weak (weak on right or left side of the body) when the muscle strength was tested using kinesiology procedures (Goodheart, 1976). Goodheart and coworkers have established an association between approximately 50 vitamins and minerals on the one hand, and 50 associated muscles which are weak when the nutrient is deficient. According to Goodheart, chewing or ingestion of the critical food factor results in dramatic restoration of muscle strength within 10 seconds. The purpose of this study was to test some of Goodheart's observations in a more formal manner and to adapt his principles to cerebral allergy testing. 10 naïve subjects were given 10 muscles tests by 6 trained testers. **Pearson Product-Moment Correlation between testers was .91, suggesting that muscle testing is reliable between testers.** Subjects with unilateral weak muscles were then given either a placebo or the nutrient which Goodheart believes to be associated with the unilateral muscle. The increase in muscle tone measured approximately 10 seconds after ingestion was 21% for the nutrient group and was statistically significant ($p < .05$) increase in comparison with the placebo group. Muscle tone was measured by a Jaymar dynamometer with the muscle tested according to kinesiology procedures described by Kendall and Kendall. In the cerebral allergy testing part of the study, a 15% decrease in muscle tone of the pectoralis major clavicular was used as the criterion for cerebral allergy. The muscle testing method was then compared to results obtained by a Philpott-type fast with progressive reintroduction of foods**. Correlation between foods identified as provocative by muscle testing and by the fast was .81. Observation of clinical results obtained with muscle testing suggests the method has substantial clinical utility.**
Muscular Strength Correlated to	*New York State Dental Journal*, 44(7);Aug/Sept 1978

Jaw Posture and the Temporomandibular Joint – Examination of a Professional Football Population, Smith, S.D.	
Evaluation of Muscle-Organ Association, Part I and II, Carpenter SA, Hoffmann, J, Mendel R	*J Clin Chiro,*1977; II(6):22-33 and III(1):42-60. **Abstract:** A study was performed at the Anglo-European College of Chiropractic to evaluate the muscle-organ association. An organ was irritated, and the muscle associated with that organ was tested with an instrument. Then a control muscle was tested. 4 organ muscle associations were evaluated: the eye, ear, stomach, and lung. The stomach was irritated by placing cold water into it; the eye with chlorinated water; the ear with sound of a controlled frequency and decibel rate; and the lung with cigarette smoke. In all cases, the associated muscle weakened significantly after the irritation. The control muscle also weakened, but to a much lesser degree. **Comment:** This paper is an important contribution to the clinical research concerning AK theory. Louisa Burns, D.O., reported in the first half of the 20th century that structural alterations of spinal vertebra produce immediately observable changes in body tissues. The connection between spinal subluxations and the muscle components that allow this structural distortion to occur are were specifically evaluated in this study. AK proposes that neurological connections exist between muscles and organs, muscles and joints and that these connections may be the basis of the chiropractor's effectiveness in correcting visceral and/or glandular dysfunction. In this study, the fact that the control muscle also weakened parallels the AK finding that general muscles of the body weaken when an insult is placed into the nervous system or other controlling factor of the body.
Relations between occlusal interference and jaw muscle activities in response to changes in head position, Funakoshi, M., Fujita, N., Takenana, S.	*J Dent Res,* 1976;35:684-690 **Abstract:** The jaw muscles responded to changes in the head position. Electromyographic responses to head positions were classified as either of two types--balanced and unbalanced. The balanced type of electromyographic responses of participants with normal occlusion changed to the unbalanced type after being set with an overlay to make a premature contact artificially, and returned to the balanced type after removal of the overlay. The unbalanced type of electromyographic response of participants with occlusal interference turned to the balanced type after occlusal adjustment. **Comment:** In AK examination and treatment, the complexity of the TMJ apparatus is appreciated. The TMJ is part of a complex system including the bones of the skull and cervical spine, the mandible and hyoid bone, the related muscle attachments and other soft tissues, and neurologic and vascular components. This complex is often referred to as the stomatognathic system. The use of AK methods, especially challenge and therapy localization, greatly assists the practitioner in finding concealed or hidden TMJ problems.
Neuromuscular control of mandibular movements, Perry, C.	*J Prosthet Dent, 1973;30:714-720*
Muscular changes associated with temporomandibular joint dysfunction, Perry, H.T., Jr.	*J.A.D.A.,* 1957;54:644-653
Electromyographic evidence for ocular muscle proprioception in man, Breinin, GM.	*Archives of Ophthalmology,* 1957;57:176-180 In this study, eye motion and position are factors shown as integrated with proprioceptors throughout the body, as well as those of the vestibular apparatus and head-on-neck reflexes. In applied kinesiology chiropractic methodology, a means for testing the integration of the muscles in the body with the visual reflexes has been termed *ocular lock.* The ocular lock

	phenomenon is theorized to be a consequence, most frequently, to cranial faults. There has been some substantiation for this premise, which demonstrates the possible effects of dural tension on the cranial nerves.
The role of binocular stress in the post-whiplash syndrome, Roy, R.	*Am J Optometry & Arch Am Acad Optometry*, Nov. 1961