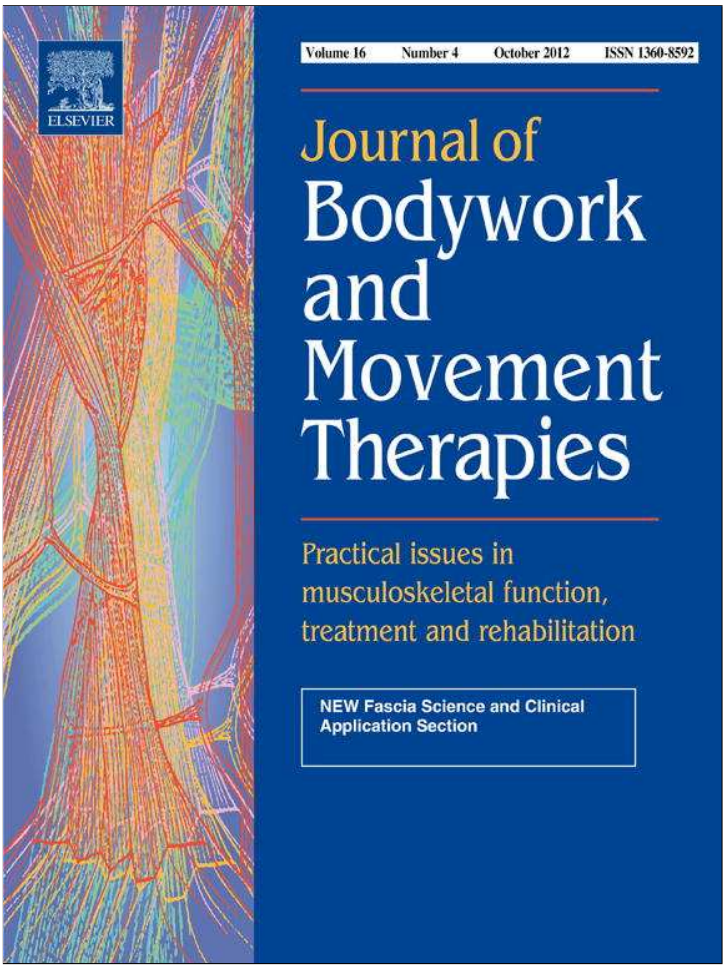

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NARRATIVE REVIEW

Applied kinesiology: Distinctions in its definition and interpretation

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Abstract Modification of the motor system in assessing and treating as well as understanding one of the causes of musculoskeletal dysfunctions is a topic of growing importance in healthcare. Applied kinesiology (AK) addresses this interest in that it is a system which attempts to evaluate numerous aspects of health (structural, chemical, and mental) by the manual testing of muscles combined with other standard methods of diagnosis. It leads to a variety of conservative, non-invasive treatments which involve joint manipulations or mobilizations, myofascial therapies, cranial techniques, meridian and acupuncture skills, clinical nutrition and dietary management, counseling skills, evaluating environmental irritants, and various reflex techniques. The effectiveness of these ancillary treatments is believed to be consistent with the expanded construct validity of the manual muscle test (MMT), as described, although this assertion has primarily been tested in outcome studies.

AK and its adjunctive procedures (challenge and therapy localization) are highlighted in this review providing details of its implementation as prescribed by an International College of Applied Kinesiology's Board of Examiners, cited for its scholarly and scientific activities. Because these procedures are believed to identify specific articular, soft tissue, biochemical, or emotional issues underlying muscle function, the applicability of this diagnostic method for all clinicians treating muscle imbalance disorders is described. As of yet, MMT efficacy in therapy localization and challenge techniques has not been established in published, peer-reviewed research.

A variety of challenges likewise remain for professional AK to establish itself as an emerging science, with numerous gaps in the literature and testable hypotheses enumerated. Of

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particular concern are a multiplicity of derivatives of AK that have been described in the literature, which should be greeted with caution in light of the fact that they lack one or more of the essential attributes of AK as described in this report. The validity of these studies which have been critical of applied kinesiology appears in many instances to be no greater than several of the randomized controlled trials, cohort studies, case control studies, and case studies found in this communication to support various aspects of applied kinesiology.

Introduction: rationale and essentials of applied kinesiology

During recent decades, modification of the motor system in both the assessment and treatment of musculoskeletal systems has emerged as a topic of growing importance (Vleeming et al., 2007; Lee, 2004; Sahrmann, 2002; Cowan et al., 2001; Suter et al., 2000). Accordingly, increased or decreased muscle activity and delayed muscular activation—phenomena which affect normal movement patterns (Janda, 1983a)—have become focal points of both clinical and research interest. It is with these facts in mind that a review of Applied Kinesiology (AK) — an integrated system of healthcare which emphasizes muscle function believed to reflect functional neurological responses—is indicated.

Briefly, AK tests muscles before and after applying a variety of challenges and treatments, making clinical judgments based on short-term changes in the muscle thereafter (Walther, 2000). It is generally considered to be a break testing methodology (Kendall et al., 2005), using a binary grading system with reference to the test muscle as "facilitated" or "strong" corresponding to a grade 5, or "functionally inhibited" or "weak" as shown by a grade 4 or less on a 0—5 scale.

In AK, the response of a particular muscle to resistance applied by a trained professional examiner was first proposed by George Goodheart to be a summation of all the excitatory and inhibitory inputs of the anterior horn motoneurons, such that a failure of the muscle in the test could be linked to a dysfunction of the nervous system (Schmitt and Yanuck, 1999; Goodheart, 1964—1998, 1988). In other words, AK has been proposed to be a study of functional neurology. Muscle changes evaluated by the manual muscle test (MMT) are suggested to be reflective of a change in the peripheral or central nervous system, and treatment is considered to be effective only if it is directed at the correct neural disruption (Schmitt and Yanuck, 1999). Disclosed primarily by muscle testing, the aforementioned neural disruption has been proposed to be brought on by disturbances in joint function, lymphatic drainage, the vascular supply to a muscle or related organ, a nutritional deficiency or excess, imbalances in the meridian system, aberrations in the stomatognathic system, or psychosocial stressors (Walther, 2000). Stated more simply, all these systems are interconnected and assumed to influence each other. AK as a tool in the study of functional neurology has been suggested to be a significant *adjunctive* diagnostic probe, used in combination with other clinical findings upon examination. An early study by Carpenter et al. (1977) was executed 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 then tested with a dynamometer. Four muscle-organ associations were evaluated: the stomach, the eye, the ear, and lungs. 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 lungs with cigarette smoke. In all cases, the associated muscle weakened significantly more than other indicator muscles after the irritation. Subsequent research was performed by Scoop (1979) to investigate AK MMT correlations with allergic patients. This study employed a Jaymar dynamometer to confirm the AK MMT findings. Schmitt and Leisman (1998) also showed a high degree of correlation between AK procedures used to identify food allergies and serum levels of immunoglobulins for those foods. Blood drawn showed that patients had antibodies to the foods which were found to be allergenic through AK assessment. Conable (2010) evaluated the AK MMT with a thin-film force transducer.

ICAK research has demonstrated correlations between positive MMT findings and other instrumentation that measure muscle force, velocity and timing (Zampagni et al., 2008; Monti et al., 1999; Leisman et al., 1995; Leisman et al., 1989) Moncayo et al. (2004) also monitored 32 patients with thyroid-associated orbitopathy (TAO) using lymph and other thyroid dysfunction measurement tools and showed that AK-guided treatment ameliorated the TAO. The broad array of AK research that correlates AK procedures with other diagnostic probes is presented in Appendix 1, and this research is presented in depth from several platforms (Cuthbert and Rosner, 2011; www.icakusa, 2011; Cuthbert and Goodheart, 2007).

The utility of analyzing disturbed body function by assessing changes affecting the muscles has been previously supported (Kendall et al., 2005; Lewit, 1999; Janda, 1978, 1983a; Kendall and Kendall, 1952). The way to differentiate previous concepts of postural disturbances and those consequent to biomechanical, biochemical, and/or psychosocial aberrations and the MMT as used in AK, is that the latter investigates the immediate changes in muscle function as the result of sensorimotor challenges to these factors taken collectively. This hypothesis was proposed in light of the evidence regarding the reliability and validity of MMT provided in 12 randomized clinical trials, 26 prospective cohort studies, 26 cross-sectional studies, and 10 case—control studies recently reviewed (Cuthbert and Goodheart, 2007). It also derives support from 35 case studies and series shown in Appendix 1, taking into consideration the fact that observational studies have recently become more accepted in constructs of evidence-based medicine (Rosner, 2012). Simons (Simons et al., 1999)

has shown that muscle dysfunction and myofascial trigger points specifically result from biomechanical, biochemical, and psychosocial influences. Biochemical and emotional factors are now considered fundamental components in holistic models of muscle dysfunction (Chaitow and Delany, 2008).

Professional applied kinesiology

The term "professional" preceding applied kinesiology (PAK) represents the practice of applied kinesiology as taught and validated by the International College of Applied Kinesiology, and its use is granted only to doctors licensed to diagnose. PAK methods are taught around the world by Diplomates in AK, who require over 300 h of classroom study with multiple instructors and 3 years of clinical practice. The Diplomate is awarded only after (a) two scholarly papers have been accepted for publication, (b) one day of written examinations is completed with passing grades in the multiple areas of [1] nutrition, [2] biomechanics, [3] viscersomatic reflexes, and [4] musculoskeletal dysfunctions (encompassing spinal, extremity, cranial and stomatognathic disturbances, soft tissue disorders relating to myofascial trigger points, strain-counter-strain, myofascial gelosis, peripheral nerve entrapments), and (c) a practical exam is successfully completed. This protocol has been applied by the International College of Applied Kinesiology (ICAK), a nonprofit foundation organized to provide a means of quality control (www.icakusa.com, 2011).

The chiropractic historian Joseph Keating describes the contributions of the ICAK as follows:

> "Unfortunately, few chiropractic membership organizations in the U.S. can claim to have been founded or to function primarily for scholarly or scientific purposes (The Association for the History of Chiropractic (AHC) and the International College of Applied Kinesinology (ICAK) are exemplary of these few.)…There are few organizations of field doctors that can make a similar claim (Keating, 1992)."

The ICAK was founded in 1976, and Keating's early recognition of the purposes of the ICAK—and its yearly publication of its membership's research reports laid the groundwork for establishing an evidence-based practice. For this statement to maintain credibility, an assessment of the strengths and weaknesses of the research literature addressing the AK procedures in conformity with the ICAK guidelines needs to be made. Such is one of two objectives of this communication. The other is to address procedures at variance with professional AK practices which have drawn substantial criticism in the literature, as will be shown in detail below.

Overview of manual muscle testing in practice

The testing of the muscle is based upon the procedures and principles of Kendall and Kendall, who, over half a century ago, established that a given muscle, when tested from a contracted position against increasing applied pressure from the examiner, could either maintain its position or break away, rated on a scale of 0—5 in terms of increasing resistance to the examiner (Kendall and Kendall, 1952). MMT reveals an *imbalance* of muscles, in which one set of muscles tends to become inhibited while another group becomes overactivated in concert (Janda, 1978). Janda argued that muscle imbalance was not readily explainable by anatomical, histological, biochemical or physiological attributes of the muscle itself (Janda, 1980, 1983a).

Accordingly, the locus of this phenomenon has been suggested to extend beyond the muscle, detectable by AK testing which is hypothesized to point to the presumed etiological dysfunction. A stimulus (touch, pressure, stimulation, mental-emotional processing, gustatory or olfactory sensation)—termed "challenge" and "therapy localization (TL)" in AK practice — if corrective in nature, is observed to produce an instantaneous strengthening of the inhibited muscle. The research to support this statement is described below, in the recent literature review of Cuthbert and Goodheart (2007) and in Appendix 1. The immediate effect of these stimuli upon muscle strength appears to be strongly influenced by patient and doctor rapport (Schmitt and Yanuck, 1999).

Added to the tenets of modern professional applied kinesiology are the facts that (1) multiple muscle tests are performed in a series or parallel manner before any diagnosis is ever made, and (2) injury and pain are not the only factors which can precipitate muscle imbalance. Aspects of individual lifestyle, such as stress, fatigue, emotional state, inadequate propriosensory input due the lack of variety of movements, and a sedentary lifestyle have been reported to be common causes as well (Jull et al., 2008; Jull and Janda, 1987). Added to these precipitating factors are such nutritional elements as vitamins and minerals, the lack of which has been suggested to produce muscle imbalance (Cuthbert, 2008; Moncayo and Moncayo, 2007; Moncayo et al., 2004; Rogowskey, 2001; Simons et al., 1999; Schmitt and Leisman, 1998; Rochiltz, 1986; Jacobs et al., 1984; Schmitt, 1982; Scopp, 1979; Carpenter et al., 1977).

Observing the change in muscle function after a patient insalivates a nutritional entity is a frequently used method of nutritional testing in Applied Kinesiology. While the nerve pathways that produce changes in muscle function remain unclear, there is evidence in the literature of efferent response throughout the body resulting from stimulation of the gustatory and olfactory receptors (Chambers et al., 2009, Guyton and Hall, 2005; Pert, 1986; Fiet et al., 1982, Yamamoto et al., 1982, Behrman and Kare, 1968). Indeed, Chambers has observed that exercise performance is improved with mouth rinsing by carbohydrate but not saccharine, supporting the specificity of oral receptors (Chambers et al., 2009), in this instance distinguishing carbohydrates from sweetness. Some of the observed reactions to sublinqual stimulation have included, for example: (1) exercise performance and brain activity (Chambers et al., 2009), (2) canine pancreatic secretion (Behrman and Kare, 1968), and (3) altered plasma levels of estrone, follicle stimulating hormone, and luteinizing hormone (Fiet et al., 1982). While changes in muscle function have been reported with subjects simply holding vials of a substance or applying them topically—to be discussed below — the ICAK has taken the position that evaluating nutritional needs by testing muscle function

should only be done when the patient stimulates the gustatory or olfactory receptors with the substance being tested. Despite the complexity of factors involved, this evaluation may become a useful adjunct to the standard methods used in determining a patient's nutritional needs (Cuthbert, 2008; Moncayo and Moncayo, 2007; Moncayo et al., 2004; Rogowskey, 2001; Simons et al., 1999; Schmitt and Leisman, 1998; Rochiltz, 1986; Jacobs et al., 1984; Schmitt, 1982; Scopp, 1979; Carpenter et al., 1977).

In addition, AK's evaluation of the activity of agonist and antagonist muscles is not primarily focused upon muscle tension and stiffness, but rather upon adaptations in which muscle *inhibition* is believed to be more prominent. This point has been amplified in the evolution of viewpoints away from muscle spasm and toward muscle inhibition in the etiology of muscle pain. Indeed, the Editor of the American Journal of Physical Medicine and Rehabilitation points out that "in spite of overwhelming evidence that skeletal muscle spasm is nonexistent, physicians are continually deluged with seductive ads to prescribe expensive muscle relaxants" (Mense and Simons, 2001; Johnson, 1989). This assertion is further supported by the observation that motor function is impaired in 5 chronic musculoskeletal pain conditions; i.e., temporomandibular disorders, muscle tension headache, fibromyalgia, chronic low back pain, and muscle soreness following exercise (Lund et al., 1991). Decreased activation for painful muscles is seen during movements in which they act as agonists and increased activation for the painful muscles' antagonists (Lund et al., 1991). This finding is consistent with the common impression that pain makes muscles difficult to use and less powerful (Mills and Edwards, 1983). The clinical relevance of this observation is borne out by recently reported impaired patterns of muscle activation and control which accompany back (Luomajoki et al., 2008) and neck pain (Falla et al., 2004a, 2004b), the latter correlating with weak and strong muscle test results obtained by AK practitioners (Cuthbert et al., 2011).

Importantly, according to Travell and Simons, an active myofascial trigger point (MTrP) will usually inhibit the function as well as the endurance of the muscle in which it is housed as well as those which lie in its target zone of referral (Simons et al., 1999). MTrPs are considered a hallmark finding of muscle pain syndromes and within clinical practice are claimed to be a common cause of musculoskeletal pain and dysfunction in people presenting for manual therapy (Bianco et al., 2006). Because muscles with MTrPs are almost always inhibited with movement and/or exertion, the hypothesis that hypertonic/tight muscles are the etiological cause of musculoskeletal dysfunction ignores the findings of the research cited above. "**Thus, if the primary source of pain is musculature, the muscle is likely to have been turned off, not on** (Mense and Simons, 2001)."

The elements of manual muscle testing (MMT) in applied kinesiology

A key element of the effective MMT is to apply pressure or resistance in a manner that allows the subject to exert the optimal response. This involves making certain that the subject does not mask a potentially inhibited muscle by recruiting others to compensate against the pressure exerted by the examiner. This phenomenon, referred to as the substitution of synergist muscle function to replace or supplant the muscle being examined, is very common (Goldberg and Neptune, 2007; Kendall et al., 2005; Daniels and Worthingham, 2003; Harms-Ringdahl, 1993; Lund et al., 1991) and demonstrates poor motor control. To minimize the probability of synergist substitution occurring during testing, a precise reckoning of the positions of the patient, examiner, and muscle being tested is required.

Timing may be a critical issue requiring further study, in that the range of duration of AK muscle testing of the middle deltoid among experienced examiners ranged from 0.3 to 3.5 s (Conable and Rosner, 2011). Elsewhere, some ICAK-trained examiners were suggested to vary technique enough to create a measurable difference in initiation of the MMT, such that the distinction between examiner-started and patient-started testing becomes blurred (Conable et al., 2005). Finally the nature of the verbal instructions or demonstrations given to the patient may create differences in the outcomes of MMT (Hyman, 2000).

An extensive checklist for effective MMT has recently been proposed by Schmitt and Cuthbert (Schmitt and Cuthbert, 2008) and is suggested to be the most current benchmark against which all AK procedures should be judged. It is in general conformity with the Technical Rules for MMT proposed by Janda (1983a) except where indicated below:

a **Is the test a standardized MMT of the muscle or is it a general test such as the "arm test?"** The tests accepted by the ICAK are grounded in the original studies of Kendall (Kendall et al., 2005) and Goodheart (Goodheart, 1964—1998). The MMT protocol as such must be consistent from test to test on the same patient and reproducible by others. By testing a general group of muscles (neck flexors or extensors, hip abductors or adductors, pelvic flexors or extensors) rather than one specifically, the tester runs the risk of obtaining a different response. For example, the "arm test" (Schwartz et al., 2009; Tschernitschek and Fink, 2005; Pothmann et al., 2001; Arnett et al., 1999; Sapega, 1990; Brand, 1989; Garrow, 1988; Quintanar and Hill, 1988; LeBoeuf et al., 1988, Kenney et al., 1988; Radin, 1984; Friedman and Weisberg, 1981) tracks all the arm flexors and abductors as a group, while the middle deltoid MMT is believed to isolate a specific muscle (Schmitt and Cuthbert, 2008; Walther, 2000). The same problem characterizes several of Janda's MMT descriptions, in which groups rather than individual muscles are emphasized in the testing (Janda, 1983a, 1983b). For example, specific testing of the sternocleidomastoid and upper trapezius muscles are not described in Janda's MMT in the evaluation of the neck, while the roles of the vastus medialis versus the vastus lateralis are not considered in the quadriceps MMT (Janda, 1983a, 1983b).

b **On how many muscles is the procedure valid?** In the ICAK, new diagnostic or manipulative treatment techniques are proposed to be evaluated using three

separate and distinct muscles, one of which is the quadriceps femoris tested in the supine position before they are considered reproducible and valid. Often the "arm test" has been described in research which fails to be reproduced when applied to another muscle, particularly the quadriceps femoris (Ludtke et al., 2001; Pothmann et al., 2001; Garrow, 1988).

c **Are the starting point and direction of force the same with each muscle testing?** These are prescribed to be consistent, the line of force not varying more than a few degrees from test to test. Failure to comply with these guidelines may result in the substitution of synergistic muscles replacing or supplanting the muscle that is being examined, likely altering the outcome.

d **Does the examiner apply the same force with the same timing on each occasion that the muscle is tested, and is the force applied at a constant rate and speed?** The force is suggested to be applied to the patient at a constant rate until the examiner senses that the muscle *begins* to give way. However, studies by Conable suggest that variability in the forces applied predominate (Conable et al., 2008). The test is characterized by a pre-loading contraction of the test muscle to maximum isometric force, followed by the examiner pushing with increased force in the direction of eccentric contraction. The muscle should *not* be tested through the entire range of motion, for, as one of the primary founders of applied kinesiology has aptly stated, "Once the muscle is in motion, the test is over" (Walther, 2000). Being able to detect this in the manner whose validity has been recognized (Cuthbert and Goodheart, 2007) requires considerable training on the part of the examiner (Caruso and Leisman, 2000; Mendell and Florence, 1990).

e **Is the contact point on the patient the same each time the muscle is tested?** Here the examiner should reproduce the contact point as precisely as possible, since the amount of leverage has been shown to affect the performance of each test (Kendall et al., 2005; Reese, 2005; Daniels and Worthingham, 2003; Walther, 2000). Specific data documenting the amount of variability allowed in these matters without altering MMT results are currently lacking. The position of the patient during the MMT should also assure the patient that he or she will not fall off the table, a fear which, without reassurance, could allow the test muscle to give way prematurely.

f **Is the point of contact on the examiner the same each time the muscle is tested?** If this varies, one could suggest that the examiner will receive different nerve impulses from the mechanoreceptors in the fingers and interpret these as varying amounts of pressure, and, more importantly, the leverage changes and the muscle fibers being tested will be different. A more systematic experimental investigation of this consideration is recommended.

g **Are the examiner's elbow, arm and forearm in the same position for each test?** This again reduces the possibility that the examiner will interpret different amounts of pressure with varying positions. It also is designed to avoid having the examiner recruit his or her whole body weight, overpowering the patient's muscle. Again, a more systematic experimental investigation of this consideration is recommended.

h **Are the examiner's shoulders in the same plane and relaxed each time the muscle is tested?** This likewise avoids having the examiner leaning over the patient, thus transferring body weight.

i **Is the examiner's body in the same position, engaging the core muscles in the same way each time the patient's muscles are tested?** Careful visual inspection of the patient during the MMT will frequently detect changes in the test parameters (Kendall et al., 2005; Walther, 2000).

What these factors essentially point to is a premise stated earlier—that the patient's reaction to the examiner's applied force in MMT is a complex *neural* phenomenon which involves both the sensory and motor systems (Reese 2005; Walther, 2000).

Validation of MMT

In a detailed literature review of manual muscle testing, Cuthbert and Goodheart point out that the careful observance of the principles of MMT described above could be found in 10 studies which yielded statistics (Cohen kappa values, interclass coefficients or percent agreement at 0.6 or higher) supporting the reliability of MMT (Cuthbert and Goodheart, 2007). Even when MMT tests were conducted over varying periods of time (1—3 s), a kappa value just under 0.6 (0.54) was obtained (Conable, 2010). Specifically, the validity of MMT (appropriateness, truthfulness, authenticity (Payton, 1994), and clinical justification or effectiveness of an observation or measurement) — can be supported from five different perspectives, both theoretical and practical:

1. *Construct and Content Validity*: This measurement can be used to make a specific inference and is the theoretical foundation upon which all other types of validity depend. These are demonstrated through logical argument rather than from experimental data:
   a. Properly innervated muscles could generate greater tension than partially innervated ones occurring in patients with anterior horn cell damage (Lovett and Martin, 1916; Martin and Lovett, 1915), except in the case of spasm due to damage to the CNS.
   b. In a hypothesis as to the causes of chronic back pain, ligament subfailure injuries have been proposed to lead to muscle control dysfunction (Panjabi, 1992). AK attempts to extend this finding by hypothesizing that this altered muscle function can be determined by MMT, supported by multiple years of clinical observations .
   c. Electromyographic activities demonstrate that patients with neck pain exhibit greater activation of accessory neck muscles during a repetitive upper limb task compared to asymptomatic controls. This is hypothesized to represent an altered pattern of motor control, compensating for the reduced

activation of painful muscles (Cuthbert et al., 2011; Falla et al., 2004a, 2004b).

d. Muscle dysfunction and its detection by MMT are related to low back pain (Arab et al., 2011; Hodges and Richardson, 1996; Janda, 1978), anterior knee pain (Mellor and Hodges, 2005), anterior groin pain (Cowan et al., 2004), ankle pain (Zampagni et al., 2008), temporomandibular joint pain (Tschernitschek and Fink, 2005), neck pain (Cuthbert et al., 2011; Falla et al., 2004a, 2004b; Ylinen et al., 2004), and patellofemoral pain syndrome (Cowan et al., 2001). (See Appendix 1)

2. *Convergent and Discriminant Validity*: MMT is able to demonstrate either strong (convergent) or low (discriminant) correlations between two variables:
   a. Patients with or without upper limb complaints could be successfully distinguished with the testing of 14 muscles (Jepsen et al., 2006).
   b. The testing of hip extensor muscles discriminated between 16 patients with and 18 patients without post-polio syndrome (Perry et al., 2004).
   c. Therapy localization (defined below) to the ileocecal valve point produced weakness in MMT, correlating with the presence of low back pain in patients with a sensitivity of 87% with this condition and a specificity of 97% lacking low back pain (Pollard et al., 2006a). The ileocecal valve point is a location on the body hypothesized to represent the function of the ileocecal valve and associated with various syndromes, including low back pain (Pollard et al., 2006b).
   d. A symptomatic group of patients with mechanical neck pain demonstrated significantly positive (weak) MMT results compared to a control group lacking neck pain, suggesting that MMT is potentially a sensitive and specific test for evaluating cervical spine muscular impairments in a patient with mechanical neck pain Specifically, 139 of 148 patients reporting neck pain showed positive MMT results in at least one of the four MMT tests, while just 30 of 100 patients without mechanical neck pain displayed such results, suggesting a sensitivity of 93.9% and a specificity of 70% (Cuthbert et al., 2011).

3. *Concurrent Validity*: The MMT may produce similar and reproducible results when compared to a similar (but not identical) test that has established its validity as a gold standard, regardless of whether the testing is done by medical doctors (Lawson and Calderon, 1997), physical therapists (Schwartz et al., 1992; Bohannon, 1986, 2001; Marino et al., 1982), or chiropractors (Perot et al., 1991; Caruso and Leisman, 2000):
   a. Comparisons of MMT test results with those obtained from a dynamometer have been successful (Bohannon, 2001, 1986; Leisman et al., 1995; Wadsworth et al., 1987; Marino et al., 1982). However, because dynamometry and electromyography measure different aspects of muscular activity, there is the possibility of obtaining false positive or false negative data (Harms-Ringdahl, 1993).
   b. For practitioners with five or more years of experience, there is a strong correlation (268 out of 274 tests administered) of the results of MMT and those obtained with a force transducer and electrogoniometer (Caruso and Leisman, 2000). The concurrent validity of the MMT (in comparison to a force transducer and goniometer) was excellent and confirmed the clinical judgments of the practitioners as far as muscle resistance and movement of the test muscles was concerned.
   c. Sequential examinations with MMT and myometry at 11 time points after spinal cord injury extending to 24-months revealed 22 of 24 correlations with p values <0.001 (Schwartz et al., 1992).
   d. Responses of the tibialis anterior muscle revealed EMG differences that correlated with the differences found between strong and weak MMT outcomes (Perot et al., 1991).

4. *Expanding Construct Validity*: In 1952, Kendall and Kendall were the first to expand the construct validity of the MMT (Kendall et al., 2005). Based on their analysis and detailed records of 12,000 cases in the physical therapy department at the Children's Hospital in Baltimore, they found positive MMT findings associated with a broad array of postural disorders and musculoskeletal symptoms far beyond the post-polio syndromes and upper motor neuron deficits that the MMT was originally designed for in the first decade of the 20th century. Furthermore, muscle dysfunctions have since been linked to the lymphatic system, the vascular system, cerebrospinal flow and the acupuncture system of meridians as well as the nervous system (Walther, 2000) This concept represents aspects of AK theory which have been amply described in numerous reliability, case and case-series reports, before-after trials, nonrandomized controlled trials, observational studies and randomized controlled studies (www.icak-usa.com, Leaf, 2010; Frost, 2002; Walther, 2002, 2000; Schmitt and Yanuck, 1999; Gin and Green, 1997; Goodheart, 1964—1998) and supported by reliability and observational studies. However, they are beyond the scope of the current discussion and in need of randomized controlled trials before the relevance of each of these factors can be confidently shown (Cuthbert and Goodheart, 2007). For these reasons, it is suggested in AK that physical, chemical, and mental/emotional disturbances are associated with secondary muscle dysfunction, affecting the anterior horn of the spinal cord and producing a measurable muscle inhibition which is often followed by the overfacilitation of an opposing muscle and producing a postural distortion (Cuthbert and Goodheart, 2007). This hypothesis is consistent with the studies of Lund and others described above (Lund et al., 1991).

5. *Clinical Justification/Effectiveness*: Numerous case studies have supported the appropriateness of AK techniques for managing clinical conditions where other treatment options have failed:
   a. Whereas oral anti-inflammatory agents, cortisone injections, and chiropractic manipulative therapy provided little relief of a congenital bowel abnormality manifesting as chronic low back pain in a 29-year-old man, the stimulation of Chapman's neurolymphatic reflexes by the patient after their analysis

together with an evaluation of traditional acupuncture meridians resolved all symptoms (Caso, 2004).

b. A 10-year-old male with a 3 year history of neck pain and headaches and 4 years of asthma attacks responded favorably to chiropractic (spinal and cranial) treatment guided by applied kinesiology in 5 treatments over a 3 week period, remaining symptom free for 2 years Previous use of medications, visits to the pediatrician and the emergency room had kept the asthma in check but did not permit exercising without significant respiratory distress. A marked increase of the patient's reading ability to his own grade level was noted as well (Cuthbert and Rosner, 2010a).
c. A 30-year-old male with a right arm contracture, atrophy, and weakness resulting in a general paralysis of the forearm and index finger responded favorably in 8 treatment sessions to conservative care guided by AK diagnostic methods, whereas previous surgical and pharmacological interventions had failed (Charles, 2011).
d. A consecutive sample of 157 children aged 6—13-years with documented histories of difficulties in reading, learning, social interaction, and school performance received a multimodal chiropractic treatment protocol, including applied kinesiology techniques. Scores in 8 standardized psychometric and 20 cognitive function tests improved after treatment, reflected by the enhanced ability of the patients to concentrate and maintain focus and attention (Cuthbert and Barras, 2009).
e. Daily stress and occasional total urinary incontinence in 21 patients aged 13—90 were significantly improved by chiropractic and applied kinesiology methods, after the identification of several inhibited muscles by MMT. Treatments ranging from 3 to 15 weeks markedly improved conditions that had persisted for up to 49 years. These improvements were observed for at least 2 years (Cuthbert and Rosner, 2011).

Thirty-three indexed, peer-reviewed case and case-series reports of positive experiences for patients (n = 1—154) treated with AK techniques have been published (Appendix 1). A review of CHIROACCESS (MANTIS) shows that since 1976, more than 500 outcomes studies (n = 1—1500) covering a broad array of Type N and Type O conditions have been published, suggesting the usefulness of AK technique in the diagnosis and treatment of patients (Cuthbert and Rosner, 2011; www.icakusa, 2011; Cuthbert and Goodheart, 2007).

Biological plausibility of "therapy localization" and "challenge" in the literature

Individuals engaged with AK theory are well aware of two adjunctive postulates. *Therapy localization* (TL), strictly diagnostic, demonstrates a change of muscle facilitation when the patient's hand is placed over an area of suspected involvement, thought to involve the cutaneomotor receptors and reflexes. *Challenge* defines a forceful stimulation imparted through the skin to affect the muscle spindles, golgi tendon organs, trigger points, and especially joint mechanoreceptors which TL cannot reach. Both are proposed to guide therapeutic interventions (Appendix 1; Walther, 2000). Given the complexity of symptoms on display in the typical patient, including pain and dysfunctional tissues or joints, one asks where would it be most appropriate to initiate treatment. Presumably, the MMT identifies the dysfunctional tissue in the locomotor system. With further sensorimotor stimulation from TL, followed by specific challenge to the underlying tissue with the positive TL, further clues would be offered in a timely fashion as to the interventions needed to correct this dysfunction.

TL was first proposed by Goodheart, who noted that, when a patient touches an area which is functioning improperly, the results of the MMT change (Goodheart, 1974). For example, if the sacroiliac articulation is dysfunctioning (thus causing the proprioceptors or myotomes to be adversely stimulated), the hamstrings may test weak. If the sacroiliac dysfunction is a functional, manipulable disorder, when the patient places his or her hand over the lesioned area of the sacroiliac joint, the hamstrings, which previously tested weak, will immediately regain normal function and test strong (Fig. 1). The articular problem(s) underlying the impaired hamstrings muscle can be quickly assayed. The patient can rapidly TL the left, then right, sacroiliac joints, the lumbar spinal articulations, the attachment points or belly of the muscle itself, and more. Each of these TLs are followed by a specific MMT to the hamstring muscle. The TL that produces the optimal response in the muscle is then treated; i.e, guided by challenge to the joint or muscle tissue found by the TL.

The essence of TL in theory is that input from low-threshold mechanoreceptors in the skin can modulate

Figure 1 If a sacroiliac somatic dysfunction is the cause of a hamstrings muscle inhibition, TL to the lesioned portion of the sacroiliac joint will strengthen the hamstring muscle immediately upon retesting.

ongoing activity in muscles. In other words, stimuli that are applied to different somatic sites may be capable of interacting in such a manner that one stimulus controls the neural activity recorded at another site. This has been demonstrated in a variety of approaches involving objective measurements in the basic sciences, often in animal studies. Anticipating this, Goodheart hypothesized that the activity of TL correlates with a spinal gating mechanism reminiscent of the gate control theory of pain perception (Goodheart, 1964—1998; Melzack and Wall, 1973). Specifically, TL stimulates mechanoreceptors, thereby influencing pain perception and muscle function. This is consistent with Hilton's Law, which states that "a nerve trunk which supplies the muscles of any given joint also supplies the muscles which move the joint and the skin over the insertions of such muscles." (Chaitow and Delany, 2008, Hilton 1863). This would imply that dermatomes are neurologically integrated with myotomes and sclerotomes, producing associated sensory and motor dysfunction. Should there be an organic or biomechanical encroachment or compression affecting the ventral nerve root, for instance, one could anticipate autonomic impairment in the associated viscerotomes and dermatomes. This is found in routine AK examinations.

Many synergistic muscle groups share common afferent inputs (Mense and Simons, 2001). This suggests that afferent stimulation from muscle spindles in one group of muscles supply the motor neurons in which they are embedded, as well as other synergistic muscles (Gielen et al., 1988). Returning to Hilton's Law, one can then appreciate a consistency, for the nerve supplying a joint supplies also the muscles which move the joint and the skin covering the insertion of these muscles.

This discussion is limited to joint, muscle, and skin receptors. Distinctions of the multiple types of glabrous skin receptors, hair cells, and juxtacapillary receptors according to morphology, sensation, rate of adaptation, and receptive field, is beyond the scope of this paper.

Evidence supporting the biological plausibility of TL is provided in human studies

1. In patients with chronic cervical radiculopathy, light pressure in the symptomatic arm is painful and accompanied by a widespread increase in EMG activity. Palpation of adjacent soft tissues is painless and unaccompanied by EMG activity. The light pressure applied is similar to what happens in TL when the patient gently touches an area of suspected injury or dysfunction, producing a change in muscle function that can be useful in diagnosis (Hall and Quinter, 1996).
2. Taping has been found to alter foot mobility and neuromotor control of gait in individuals with leg pain (Franettovich et al., 2010) as well as pain-free grip strength and pressure pain thresholds (Vicenzino et al., 2003). The light pressure applied could serve as a demonstration of what occurs in TL.
3. Strong synaptic coupling exists between the tactile afferents in the sole of the foot and motoneurons supplying muscles that act about the ankle. This was shown with microelectrodes which were inserted percutaneously into the tibial nerve of human subjects, in which reflex modulations of whole muscle electromyography (EMG) were observed for each of 4 classes of low-threshold cutaneous mechanoreceptors. Simply stated, this study demonstrates that stimulation of the skin may be responsible for changes in muscle strength, which is the basic tenet of TL. Indeed, the cutaneomuscular reflexes observed may be themselves a part of the mechanism of TL (Fallon et al., 2005; Nicholas et al., 1980).
4. EMG recordings in 15 patients demonstrated that stimulation of the median nerve reduced the size and number of descending corticospinal volleys that were evoked by transcranial magnetic stimulation in relaxed or active muscle. This suggested that mixed or cutaneous input from the hand can suppress the excitability of the motor cortex at short latency, which may contribute to the initial inhibition of the cutaneomuscular reflex. This, in turn, would be expected to reflect in changes in muscular strength in MMT, which would be the essence of TL (Tokimura et al., 2000).

However, none of these approaches have yet accounted for operator and patient expectations during the process of TL, which could produce changes in muscle function. An experimental procedure which would shed light on this phenomenon and possibly rule out this confounding factor would be to assign an intermediary to covertly signal to the patient whether or not to perform a TL which is hidden from the examiner during a MMT. Although the patient in this fashion could not be blinded, the examiner would make a judgment free from the bias of observing whether or not a TL has been performed. A step in this direction was recently achieved by Pollard and his coworkers, who obtained fair to substantial agreement between 2 practitioners testing 6 proximal leg muscles when all visual, verbal and nonverbal cues were removed from view of the assessing practitioners. Specifically, participants were instructed to avoid all communication with the practitioners or give them any visual cues to maintain blinding in the study. Practitioners, on the other hand, were instructed to exit the room whenever the patient changed position so as to avoid any cues regarding the pain status of the participant. The percentage of correct responses from both practitioners was represented as kappa scores of 0.21—0.8, depending upon the muscles tested (Pollard et al., 2011).

Other findings supporting the concept of TL occur in *animal studies*

1. In cats, microelectrode recordings in the thoracic cord reveal that cells located in the lamina 5 respond to both the fine myelinated afferents from the splanchnic nerve as well as to afferents from the skin, suggesting the convergence of signals (Hoheisel and Mense, 1990; Pomeranz et al., 1968).
2. In cats, thermal and mechanical stimulation of the skin at various segmental levels elicit reflex changes in the heart rate (Kaufman et al., 1977).
3. In rats, colorectal distention produces a viscerosomatic reflex, as quantified by taking electromyographic EMG

recordings from the external oblique muscle of the upper abdomen (Shafton et al., 2006).
4. In rats, afferent inputs from the skin and viscera affect both the activity of both the bladder and skeletal muscle surrounding the urethra (Morrison et al., 1995).

Although these findings could be used to support TL speculations, no research has been published to support the hypothesis that patient hand contact could evoke responses such as those using MMT. Such investigations are currently in progress.

The third element of AK, as previously described, is challenge. After an external stimulus is applied, MMT is performed a second time to determine whether or not a change in muscle strength has occurred. An example of this procedure would be to conduct a MMT of a muscle crossing or attaching to the knee. The physical challenge of reducing the misalignment suspected in the articulation of the knee would strengthen the weak muscle, confirming the neurological inhibition that was originating at the knee and demonstrating the angle of correction needed to strengthen the inhibited muscles(s). The physical manipulation in the direction of the positive challenge would then abolish the inhibition (Fig. 2). The reader will note the similarity to TL, except that TL is restricted to light touch of a cutaneous area and is customarily performed by the patient.

Both challenge and TL may help to steer the therapist away from areas that produce no change in muscle strength, such that treatment alternatives to the patient are narrowed and the therapy becomes more efficient.

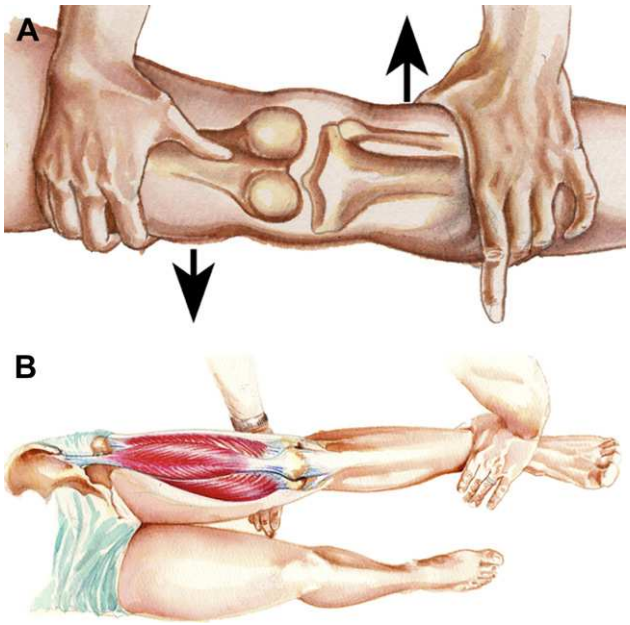

Figure 2 Pressure ("challenge") in the direction of the arrows will improve the position of the knee somatic dysfunction and strengthen the quadriceps muscle which is presumed to be weak because of the somatic dysfunction. It is suggested that manipulative correction in the directions of the arrows will stabilize the joint somatic dysfunction and its consequent inhibition of the quadriceps muscle.

Cranial challenge has previously been described in the literature (Cuthbert and Barras, 2009; Cuthbert and Blum, 2005).

Sensorimotor challenges: the evolution of a method of assessment

The visual diagnosis of a specific joint disturbance in the body and simultaneously evaluating its relationship to specific local or remote muscle impairments has been described to be "fraught with difficulty" (Lederman, 2010). The different elements within the chain of events that a patient performs in front of the examiner occur within a fraction of a second, too rapidly to be accessed individually in the absence of laboratory tools. Therefore, what is actually observed by the examiner who depends upon visual diagnosis of muscle-joint interactions is the grand total of how rapidly and smoothly a person's global posture changes between two activities. However, it is almost impossible to make a diagnosis of a specific muscle or joint dysfunction on this basis (Jarosz, 2010; Lederman, 2010).

Regarding the assessment of the sacroiliac joint by way of example, the development and practicality of AK theory can be best appreciated by the following:

1. Prone Hip Extension:

The Prone Hip Extension (PHE) test was developed by Janda et al. (2006) as a means of assessing motor control of specific low back and thigh muscles. Janda claimed that the altered movement patterns of the muscles proximal to the sacroiliac joints in patients with dysfunctions could be detected by observation alone, with light palpation added if the visualization of the imbalance was unclear for a variety of reasons (Fig. 3). During the PHE test, the physician observed and/or palpated the ipsilateral gluteus maximus, ipsilateral hamstring, ipsilateral erector spinae, and contralateral erector spinae muscles in order to determine the order of activation. Janda theorized that the muscle activation sequence during the PHE simulated the muscle recruitment pattern of hip extension during gait (Fig. 4).

2. Form Closure of the Sacroiliac Joint:

Vleeming et al. (2007); Lee (2004) in their "form and force closure" model of the sacroiliac joint function have

Figure 3 Abnormal PHE test with palpation.

Figure 4 Abnormal PHE test: In this test there is a lumbar extension, anterior pelvic tilt, and knee flexion.

added a sensorimotor challenge for the assessment of joint dysfunction's influence upon muscular strength and range of motion. This method helps diagnose the structures implicated in the movement impairments of the PHE test. Vleeming and Lee's functional tests help the clinician determine the characteristics of form and/or force closure problems in a particular joint by using tests that identify improved function and ranges of motion (Fig. 5).

3. AK sensorimotor challenge

Because of the difficulties in accurately measuring visual changes in movement patterns, and thereby diagnosing the specific muscle or joint impairments responsible for the altered movement patterns found, Goodheart (Goodheart, 1973, 1972) developed a method of assessment that permitted a specific sensorimotor challenge to a muscle or joint to be immediately followed by a specific MMT to a local or distant joint or muscle; if these factors were connected, then an immediate change in strength of the muscle was seen to occur.

In other words, in the AK model of sacroiliac assessment, instead of using a visual test for a change in movement after the physical challenge to the joint, what has been defined as the AK sensorimotor challenge is followed by a MMT for a change in strength. In most sacroiliac joint dysfunctions, there will be a combination of vectors during the challenge procedure that causes the maximum amount of strengthening of the indicator muscle. This becomes the optimal vector for correction as well, the diagnostic test leading to a presumably more precise treatment.(Fig. 6).

To sum up, in the AK assessment of the sacroiliac joint, the specific functional strengths of the gluteus maximus, gluteus medius, piriformis, quadriceps, abdominals, hamstrings (biceps femoris, vastus lateralis and medius) and latissimus dorsi—critical to the adequate force closure of the sacroiliac joint (Vleeming et al., 2007) — are tested. Additionally, the effect of stabilization (the AK sensorimotor challenge) of proximal or distal structures like the sacroiliac joints, lumbar vertebral joints, cervical spine (with TL and challenge) upon each of these muscle's functions is an important addition to the AK system of analysis. The MMT of each of the muscles involved (and their association to one or more structures located locally or distally) is believed to untangle these complex adaptations to sacroiliac joint dysfunctions. In addition, the AK methods of TL and challenge offer further insight into the PHE test (Fig. 7).

Specifically, Cuthbert (2012) presented an outcomes analysis of the tests developed by Vleeming et al. (2007); Lee (2004); Janda (1983a) when the AK procedures of TL and challenge were added to these tests. This study demonstrated that measurable improvements in range of motion occurred when TL or challenge were applied to a dysfunctional area in the patient, and produced improvements in the range of motion of the PHE and form and closure tests.

Figure 5 With "form closure" of the sacroiliac joint augmented (the sacroiliac joint approximated), the prone straight leg raise is visually improved.

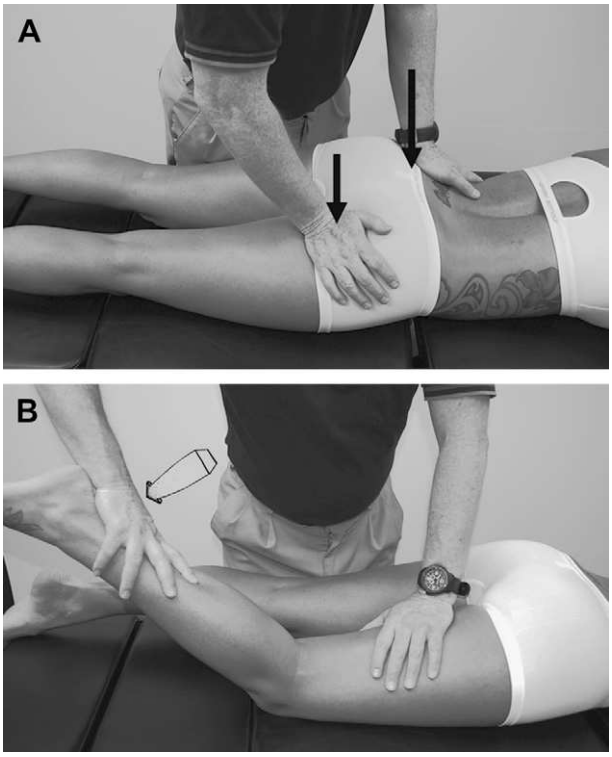

Figure 6 The AK sacroiliac challenge (right ischium, left ilium) produces immediate strengthening of the previously inhibited ipsilateral hamstring muscle.

Figure 7 As Janda proposed (Janda, 1964) in sacroiliac strains, the ipsilateral gluteus maximus will test weak. With TL to the sacroiliac joint, the gluteus maximus tests stronger—or, in this scenario, the PHE test is improved. TL allows for the rapid sensorimotor stimulation of many different areas (e.g., the upper neck, lumbar spine, and jaw) until the one correcting the test or inhibited MMT is found.

Nutritional evaluation in AK

The potential of nutritional MMT performed by AK practitioners was demonstrated in one positive pilot study which confirmed 19 of 21 food allergies by a radio-allergosorbent test (RAST) and immune complex tests for IgE and IgG against 21 foods that produced muscle weakening (inhibition) reactions with oral provocation. Subjects, but not practitioners, appear to have been blinded in the study (Schmitt and Leisman, 1998). Several failures to confirm the validity of nutritional testing have also appeared in the literature, however.

Because of neurological involvement, training, and positioning issues raised earlier, MMT in professional AK is a highly complex and skilled undertaking. In a status statement published in 1983 and updated in 1987, the International College of Applied Kinesiology stated:

> "Nutritional evaluation (by muscle testing) should be done only with the subject tasting the substance. It is also necessary to evaluate other factors which may influence the perceived muscle strength. Confirming diagnostic criteria for the need of any nutrition should be present from the patient's other diagnostic work-up, which may include history, type of dysfunction, laboratory tests, physical diagnosis, and dietary inadequacies…An adequate educational background is needed in evaluating nutritional needs and manual muscle testing. (International College of Applied Kinesiology, 1984)."

Accordingly, the likelihood of omitting or misinterpreting essential elements of AK from the derivative procedures that have been cited in the literature is high, such that many of the criticisms of MMT in AK may have been directed at renderings of AK not performed by individuals specifically trained in professional AK. Indeed, from the very beginnings of AK, Goodheart wrote that lingual receptors must be stimulated in order to perform reliable and reproducible nutritional testing. His research manuals repeatedly state that "holding a glass vial of pills" or "laying pills or substances on the chest" were inappropriate procedures because the responses were not predictable, to say nothing of inexplicable (Goodheart, 1964—1998). Hambrick (2007) confirms this by showing that 5 examiners found little correlation between "on-the-body" testing of toxic substances (that normally would inhibit a patient due to their noxious chemistry) and MMT findings. The taste receptors on the tongue respond to even miniscule concentrations of substances within a fraction of a second of stimulation (Guyton and Hall, 2005). Exposure to taste elicits a variety of immediate neurological, digestive, endocrine, circulatory, and renal responses throughout the body and has been called the cephalic or preabsorptive response (Mattes, 1997).

Critical assessment of AK in the literature

A review of 20 Applied Kinesiology papers sampled from a non-refereed source (International College of Applied Kinesiology, 1981—1987) reported that no studies contained all 9 of the methodological attributes judged and described above to be important criteria for research quality. For example, 12 of 15 studies required a control group but had none; 13 of 14 failed to include a required blind assessor, and none presented an acceptable statistical analysis. Other criteria deemed to be of importance but not consistently appearing in the studies included (1) sufficient sample size,(2) inclusion criteria, (3) a reliable test mechanism, and (4) the use of blind and naïve subjects (Klinkowski and LeBoeuf, 1990).

It is important to note that Klinlowski's review chose a source of research presentations that circumvented the peer review process of a typical refereed medical journal. In the more than 20 years since this review was published, the papers which have actually appeared in peer-reviewed journals as cited in this discussion have shown progress overall with their use of inclusion criteria, incorporation of control groups, and use of a more reliable MMT often supported with statistics (Conable, 2010; Cuthbert and Goodheart, 2007). The most critical areas still requiring attention involve sample sizes and the blinding of assessor, subjects and examiners. Large-scale randomized controlled trials are not yet present in the research portfolio. However, the abundance of observational research studies appearing in the indexed journals must be noted (Appendix 1), together with the findings that more recent observational studies have been deemed to possess predictive abilities similar to those from clinical trials (Benson and Hartz, 2000; Concato, 2000). The fact remains that all healthcare interventions are presently in need of a broad cross-section of clinical research designs to achieve complete documentation, such that the concept of evidence-based medicine itself is worth revisiting (Rosner, 2012). An indication that this diverse documentation of AK has already begun to appear in the peer-reviewed journals is already available (http://www.icakusa.com/wp-content/uploads/2011/08/AK-Research-Compendium-Dr-Scott-Cuthbert-10-08-11-LATEST.pdf).

Generally, many procedures which have derived from AK do not appreciate that:

1. It is misleading to attach all one's confidence to objective measurements of the strengths of muscles (including handheld dynamometry, fixed frame dynamometry, and isokinetic measurements). All of these

yield a vast range of strength scores which do not yet have reliable reference values. Under such circumstances, their associated errors in clinical determinations have not yet been fully established (Dvir and Prushansky, 2008).

2. The investigations byTriano (1982), while correctly blinding both patient and practitioner from various nutritional extracts tested, failed to distinguish MMT strengthening of the latissimus dorsi (LD) when tissue substances from a variety of sources were administered either sublingually or topically. The LD, originally found to be inhibited, responded with roughly equal probability despite the source (pancreatic, cardiac, thymic, or testicular) of the extract, contradicting the opinions of ICAK Diplomate members that the pancreatic extract should have exhibited a unique strengthening effect. However, numerous flaws substantially weaken this investigation's conclusions:
   a. The tests were conducted on lingual receptors instead of the sublingual species described, a descriptive and rather common error (Goodheart, 1983).
   b. There is no indication that subjects underwent a washout period prior to testing, such as fasting or avoiding cosmetics or body lotions for at least 12 h before experimental procedures were begun.
   c. There is no indication of medications taken by the subjects, which could have confounded results.
   d. For the ingested substances, no effort was made to rinse the mouth between administrations—increasing the possibility of carryover.
   e. There is no indication that the subjects were monitored closely enough to avoid changes in the test position or recruitment of synergistic muscles during the duration of their individual tests.
   f. It has been shown elsewhere that no single nutritional factor correlates with a specific muscle per se; rather, the overall health (including emotional state) of the patient influences to what extent muscle function will change in response to nutrients (Leaf, 1985). Reference is made to the quotation stated above regarding the complexity of nutritional testing (International College of Applied Kinesiology, 1984). The finding that all subjects in response to all substances administered using either challenge procedure (ingestion or topical application) displayed muscle strengthening only 25% of the time on the average with little deviation might suggest that numerous other confounding factors affected muscle reactivity.

Nevertheless, the research repeating Triano's design including the controls suggested above has yet to be performed. Triano has correctly pointed out that he would welcome the replication of his study pending an objective characterization of the perceived weak muscle (Triano, 1983), but the discouragement of further investigations in his original article (Triano, 1982) along with the usage of such terms as "obvious lack of foundation" and "purported" are problematical and detract from the need for objectivity and replication in research (Poortinga, 1983).

3. "Kinesiology" as defined by several negative studies (Schwartz et al., 2009; Hall et al., 2008; Haas et al., 2007; Kendler and Keating, 2003; Ludtke et al., 2001; Arnett et al., 1999; Sapega, 1990; Brand, 1989; Quintanar and Hill, 1988; Kenney et al., 1988; Radin, 1984; Friedman and Weisberg, 1981) fails to meet the educational and training standards of MMT described above and omits citing—let alone discussing — most of the research literature supporting AK:
   a. A literature review which is critical of AK (Hall et al., 2008) discusses various adaptations of a derivative procedure called Touch for Health (a derivative approach that uses acupressure, massage and touch in order to reduce pain, improve postural balance, and alleviate tension) rather than the specific methods in AK:
   b. Another widely cited study addressing nutritional MMT evaluated 11 subjects independently by 3 examiners for 4 nutrients and failed to demonstrate any correlation of MMT results with either laboratory determinations of blood levels of the nutrients or muscle contraction using a Cybex II dynamometer (Kenney et al., 1988).
      1] The most apparent problem in this report was that it utilized two lay persons and a chiropractor using Ridler points as the reflex points for testing. A search of PubMed and MANTIS can find no evidence beyond the Kenny study for the validity of using Ridler points. It was pointed out (Goodheart, 1968) that this approach could not have involved professional AK; rather, the investigation had been carried out by a majority of persons not licensed as health practitioners, thus being ineligible to gain professional status in AK from the International College of Applied Kinesiology.
      2] The typical nutritional test chart presented in this report is not a part of AK, nor has it ever been printed in the AK literature.
      3] The article states that "muscle response for testing for possible nutritional deficiencies is an intuitive science." While there may be an element of intuition which is refined with experience (Caruso and Leisman, 2000; Mendell and Florence, 1990), the statement as such fails to justify the authors' departure from the protocol observed in AK, outlined earlier in this report.
      4] The study failed to demonstrate intra- and inter-examiner reliability among the 3 examiners, in contrast to the data in these respects for AK (Cuthbert and Goodheart, 2007).
   c. The "arm test" as described in several investigations (Schwartz et al., 2009; Tschernitschek and Fink, 2005; Pothmann et al., 2001; Arnett et al., 1999; Sapega, 1990; Brand, 1989; Garrow, 1988; Quintanar and Hill, 1988; Kenney et al., 1988; Radin, 1984; Friedman and Weisberg, 1981) ignores most of the facets of AK described above.
   d. In evaluating possible effects of nutrient, vitamin, or mineral deficiencies in MMT, numerous studies (Schwartz et al., 2009; Kendler and Keating, 2003; Ludtke et al., 2001; Arnett et al., 1999; Sapega, 1990; Brand, 1989; Kenney et al., 1988; Quintanar

and Hill, 1988; Radin, 1984; Friedman and Weisberg, 1981) erroneously assume that nutritional challenges can be performed by bypassing the gustatory or olfactory response, which is an essential component of AK. Taking such liberties may invite criticisms which are not germane to AK.

4. Another widely cited study (Rybeck and Swenson, 1980) addressed to nutritional MMT correctly placed sugar in the subjects' mouth while comparing the results of MMT of the latissimus dorsi against a mechanical test (peak reading on a force transducer). While changes in MMT correlated with the presence or absence of sugar, they did not with the force transducer:
   a. The lack of correlation of MMT and the mechanical device is not surprising, given that there is an inherent difference in parameters measured in manual and mechanical testing, as mentioned earlier (Harms-Ringdahl, 1993).
   b. Both the sensitivity and reproducibility of the mechanical device were not evaluated and could be lacking.
5. A presentation of AK available in many bookstores (Hawkins, 2002) creates a lengthy list of statements and assumptions which are at major variance with what has been described by the acknowledged founders of AK (Walther, 2000; Goodheart, 1964-1998) and the requirements of professional training as recognized by the International College of Applied Kinesiology (www.icakusa.com, 2011). Among the more problematical statements are such assertions that:
   a. Weak muscle testing results are always obtained if the subject is presented with a statement which involves a falsehood, a political dictator, or even heavy metal music.
   b. Subjects may distinguish original works of art from copies by means of AK testing.
   c. Numerous calculations drawn from kinesiological testing conclude that the advance of consciousness throughout the global population has been little more than 5 points during a lifetime.

In presenting a variety of arbitrary assumptions whose validity seems unlikely, this work depicts a popularized form of AK which bears little or no resemblance to the accredited AK procedures which this communication has attempted to define.

A randomized controlled trial which appears to refute AK and challenge procedures was published by Haas and his coworkers in 1994, employing 68 naïve volunteers from the student body, staff and faculty of a chiropractic college. The provocative vertebral challenge applied was a standardized 4—5 kg force delivered with a pressure algometer to the lateral aspects of the T3-T12 spinous processes. The therapeutic intervention was a manual high velocity low amplitude adjustment or switched-off Activator instrument used as a sham. Reactivity of the piriformis muscle following a vertebral challenge was assessed, together with responsiveness following spinal manipulation. Because the percent of the reactivity to the vertebral challenge was only 16% with 0% responsiveness to spinal manipulation, it was concluded that the muscle response seemed to be a random occurrence unrelated to the manipulable somatic dysfunction. The conclusion was that MMT seemed to be of questionable use for spinal screening and post-adjustive evaluation (Haas et al., 1994).

The procedure was well-designed in that the sham procedure using the zero Activator setting more closely resembled a true placebo as can be obtained in manual medicine. It was helpful to the reader that Haas distinguished manual muscle testing per se from its application by AK, the specifics of which have been elegantly outlined more recently (Conable and Rosner, 2011), and which, in fact, this discussion attempts to emphasize in arriving at a clearer understanding of AK. The concern with Haas' investigation, however, was that the majority of the subjects investigated (60%) lacked pain with only half having stiffness in the thoracic region. Vertebrae without subluxation (somatic dysfunction), fixation, or other mechanical problems should be negative to challenge. Positive results from challenge to the thoracic spinal column from T3 to T12 in this experiment would therefore be expected to be scanty. Furthermore, the specific vector of challenge must match the specific somatic dysfunction of the vertebra if changes in MMT are to be found and the challenge procedure is to be of any use in guiding subsequent therapeutic interventions. General lateral to medial spinous process pressures applied to a vertebra that may be asymmetrically positioned, do not always produce the sought-after muscle responses.

In summary, the validity of numerous studies which have been critical of applied kinesiology appears in many instances to be no greater than several of the randomized controlled trials, cohort studies, case control studies, and case studies found in this communication to support various aspects of applied kinesiology.

Critical areas of investigation yet to be completed

For an intervention that is just five decades in existence (Goodheart, 1964—1998), AK despite its suggestive promise has several areas yet to be firmly tested by the following general questions in order to be able to secure its scientific basis:

1. What is the intraobserver repeatability of MMT with or without TL over short periods of time? And over longer periods to assess possible diurnal effects?
2. Are the same effects of TL observed when (a) the examiner is blinded to the areas touched by the patient, or (b) the patient is told to expect a specific effect?
3. What amount of variability of contact points of the patient and examiner affect the results of the MMT?
4. What are the effects of blinding the patient from the examiner, both in MMT in the clear (i.e. before specific muscle testing commences) and with TL?
5. What are the outcomes in nutritional testing with both patient and examiner blinded?
6. What factors such as stress, previous exertion, fasting, or lack of sleep affect the results of MMT, either in the clear (i.e. before specific muscle testing commences), with TL, or in the presence of a nutritional substance?

7. What are the effects of commonly used medications upon MMT?

Conclusions: a users' guide to AK

Professional AK, a refinement of muscle testing procedures, may provide a notable array of diagnostic benefits in practice. While certain aspects of its scientific plausibility and validity can be supported by the modest evidence described in this report, several critical areas regarding its repeatability in the presence of a multiplicity of confounding factors have yet to be established. As of yet, MMT efficacy in therapy localization and challenge techniques has not been established in published, peer-reviewed research. AK's historical focus upon aberrations in motor and afferent neural activity allows it to provide insight into a broad spectrum of clinical ailments, often at an early stage and therefore most amenable to treatment. To avoid some of the criticisms which have been leveled against AK, a professional training regimen which benefits from the most extensive support in the literature as described in this communication would be indicated. Various forms of AK which display the following characteristics may or may not achieve positive and reproducible results in MMT. They should always be greeted with caution in light of the fact that they lack one or more of the validating attributes of AK:

1. Practitioners who are not licensed by their states to provide diagnoses;
2. Practitioners who have not had sufficient professional training in AK;
3. Practitioners who do not follow in detail the procedural requirements of AK described in this report;
4. MMTs that are conducted in isolation, neither in series or parallel fashion with the MMT of additional muscles nor as adjuncts to other diagnostic procedures;
5. MMTs which rely solely rather than partially upon instrumentation for their validation, given that neural components evaluated by MMT may not be measurable by the instrumentation employed;
6. Nutritional MMTs that are conducted with subjects holding rather than tasting the substance of interest, failing to engage the gustatory and/or olfactory receptors;
7. Nutritional testing which fails to emphasize individual patient considerations to account for biochemical individuality.

This guide is intended to provide a foundation upon which more productive dialogues concerning AK research and practice can ensue. It also may help to create a clearer channel through which multiple health professions can be expected to collaborate and better manage their patients.

Acknowledgments

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Appendix 1

Support of AK validity: characteristics of 33 case reports of positive experiences for patients (n = 1–154) assessed and treated with AK MMT methods (RCTs indicated by **).

Authors, date	Diagnosis	Subject(s)	Repeated Observations	Treatments	Outcomes
Cuthbert and Rosner (2012)	Urinary Incontinence (UI), daily stress UI and occasional total UI, requiring sanitary pads	21	AK MMT examination and symptom reports. Positive MMT of the pelvic, pelvic floor, and lumbar spine muscles appeared in every case with UI.	Spinal manipulation, flexion-distraction treatment, soft tissue treatment and percussion to myofascial trigger points — each of which produced inhibition in the pelvic floor muscles.	Lumbo-sacral nerve root dysfunction confirmed in 13 of these cases with pain provocation tests (AK sensorimotor challenge); in 8 cases this challenge was absent. AK treatment normalized symptoms in 10 patients, considerably improved 7 cases, and slightly improved 4 cases from between 2 and 6-years.
Cuthbert and Rosner (2011)	Insomnia, anxiety, breathlessness, headache	64-year-old female	AK MMT examination, visual analog scale, symptom reports, and Nijmegian questionnaire	AK spinal, cranial and soft tissue treatment to address hyperventilation syndrome, pineal gland cranial faults.	After 1st 65-min treatment, patient reported her fatigue, brain fog, and anxiety were improved. Over 10 day period (4 treatments), patient's sleep difficulties and anxiety syndromes were resolved and remained so for 3 years. Nijmegen questionnaire for hyperventilation syndrome markedly improved.

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Appendix (*continued*)

Authors, date	Diagnosis	Subject(s)	Repeated Observations	Treatments	Outcomes
Charles (2011)	Parsonage-Turner Syndrome	30-year-old male with right arm paralysis	AK MMT examination and symptom reports	Spinal manipulation, soft tissue treatment to myofascial trigger points, exercises and stretches.	Improved range of motion after first treatment session. By the eighth treatment, able to fully straighten arm. Three years later, patient able to mountain climb with arm fully functional and pain-free.
Cuthbert and Rosner (2011)	Urinary incontinence (UI), requiring sanitary pads	13-year-old female, following emergency appendectomy surgery	AK MMT examination and symptom reports	Spinal manipulation, soft tissue treatment and percussion to myofascial trigger points — each of which produced inhibition in the pelvic floor muscles.	Patient experienced a rapid resolution of her UI. A six-year follow up confirmed complete resolution of symptoms.
Cuthbert and Rosner (2010b)	Severe daily headaches, 7-years duration	56-year-old female, following 3 motor vehicle accidents	AK MMT examination, Visual analog scale, and symptom reports	AK-guided chiropractic manipulative therapy and cranial evaluation and treatment.	8 visits during a 3 week period relieved virtually all symptomatology with the score of 0 on the neck and low back pain visual analog scales (VAS).The patient remained free of her original symptoms for 8 years.
Cuthbert and Rosner (2010a)	Developmental delay syndromes, asthma, and chronic neck and head pain	10-year-old male, using 4 medications for asthma. Poor reader (unable to move easily from one line of text to another during reading), suffered eye strain while reading, and poor memory for classroom material.	AK MMT examination, parental and school symptom reports	AK-guided chiropractic manipulative therapy, and cranial evaluation and treatment	Child's ability to read improved (in 3 weeks, after 5 treatments), performing at his own grade level. Remains symptom free for 2 years.
Masarsky and Todres-Masarsky (2011)	Evaluation of divergent thinking after a single chiropractic intervention	16 subjects, 15 of whom involved in creative thinking work), aged 28—73 yoa; 13 with musculoskeletal pains; 2 under emotional stress	Pre- and post-treatment involved MMT and "alternate uses" assessment tests (an established outcome measure related to divergent thinking). Subjects interviewed 1—9 days after treatment for changes in creative output.	1 session of AK spinal and cranial treatment	Pooled data of the two reports show a statistically significant ($p = .030189$) short-term enhancement of creative thinking or energy/focus when involved in creative work following treatment.

Masarsky and Todres-Masarsky (2010)	Evaluation of divergent thinking after a single chiropractic intervention	10 established patients, 9 of whom involved in creative thinking work; 3 under stress; 7 with musculoskeletal pains	Pre- and post-treatment involved MMT and "alternate uses" assessment tests (an established outcome measure related to divergent thinking). Subjects interviewed 2—8 days after treatment for changes in creative output.	1 session of AK spinal and cranial treatment	6 of the 10 subjects experienced a post-adjustment improvement in their performance on the alternate uses test. Interview responses indicated new directions in a real-world creative task for 7 of the subjects, and renewed energy towarda creative project already planned for 6 subjects. None of the subjects gave any indication on interview that their creativity had suffered in any way. "Taken as a whole, the results suggest short-term enhancement of creative thinking following a chiropractic adjustment."
Cuthbert and Rosner (2010c)	Sciatic neuralgia, plantar fasciitis, and restless leg syndrome	78-year-old male	AK MMT examination and symptom reports	AK spinal and nutritional treatment	Patient was symptom free within 3 weeks, with no recurrence of symptoms reported after 7-years.
Cuthbert and Rosner (2010d)	Recurrent, monthly ear infections since the 4-months of age with severe postural imbalance and candidiasis	6-year-old female who had undergone antibiotic treatment 25 times	AK MMT examination and symptom reports	AK spinal, cranial, and nutritional treatment	Child has been symptom free for 3 years since her first 4 AK treatments over a 3-month period.
Cuthbert and Barras (2009)	Developmental Delay Syndromes (dyspraxia, dyslexia, ADHD, learning disabilities)	157 children aged 6—13-years (86 boys and 71 girls)	MMT and a series of 8 psychometric tests given to the children by a certified speech therapist pre- and post-treatment; i.e. Complex figure of Rey Test; Borel—Maisonny Test (Logatomes); Porteus Maze Test; Oriented Signs Test; Auditory Memory Test of Rey; Piaget—Head Tests; Rhythm Reproduction Test of Stamback; and Facial Motricity Test of Stamback.	AK spinal and cranial manipulative treatment	The most common feature in DDS is motor impairments. Psychometric testing evaluating cognitive function showed good improvements after AK treatment in children with DDS. The suggested link between motor impairments and DDS described in the literature and the muscle inhibitions found with manual muscle testing (MMT) in this group of children was confirmed.

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Appendix (*continued*)

Authors, date	Diagnosis	Subject(s)	Repeated Observations	Treatments	Outcomes
Moncayo and Moncayo (2009)	6 volunteers with normal muscle function	4 medical students and 2 medical doctors	MMT and sEMG assessment of the rectus femoris muscle	Stimulation of sedation point (followed by sEMG measurement of the muscle), and stimulation of tonification point (followed by sEMG measurement of the muscle), for stomach meridian/rectus femoris muscle.	Stimulation of sedation point for rectus femoris muscle produced a decrease in sEMG amplitude; stimulation of tonification point for rectus femoris muscle produced an increase in sEMG amplitude. From the conclusion: "We have been able to demonstrate one of the working principles of Applied Kinesiology in relation to tonification or sedation through the use of specific acupuncture points."
Garten (2008)	Cervical dystonia (spasmodic torticollis)				
Cuthbert (2008)	Asthma & diaphragm muscle impairment	10 patients (7 male, 3 female, between ages of 3 and 22.	AK MMT assessments and visual analog respiratory impairment scales, self- or parent-reported improvement in exercise-induced asthma symptoms, reduction of respiratory distress with daily activity, reduction in the frequency of coughing during the day and night, and ease of breathing.	AK manipulative treatment methods	Each patient able to go off their asthma medications after a range of 3—6 visits (covering a range of 14 days to 5 months time) without a return of their asthma symptoms. All patients remained off their medications during follow up period ranging from 3-months to 4 years.
Cuthbert (2007)	Down's syndrome	12 children (11 boys, 1 girl), ages 11 months to 10.5 years.	Cranial palpation and "surrogate" manual muscle testing	Cranial, spinal, nutritional, and meridian AK treatments.	Correction of primary complaints in these children, including: vomiting or spitting up after feeding, gastrointestinal difficulties, asymmetrical motion of arms or legs; mixed dominance; spells of ceaseless crying, lack of sequence or missing stages in motor development; dysfunctions with visual and auditory skills; frequent ear infections and sinusitis.

Cuthbert (2005)	Motion sickness disorder	1: 66 yoa female 2: 45 yoa female 3: 9 yoa female	Proprioceptive testing (Freeman-Wyke and Hautant's tests), AK MMT and palpation	Spinal and cranial chiropractic manipulative therapy (CMT)	1: Able to drive car and ride in a boat and airplane symptom free after 4 visits. 2: Able to drive car symptom free after 6 visits. 3: Able to drive in car symptom free after 4 visits
Cuthbert and Blum (2005)	Optic nerve neuritis exacerbated by an Arnold-Chiari malformation (Type I) of the cerebellum	1: 20 yoa female	AK MMT to diagnose vertebral subluxations and cranial lesions; ocular muscle testing, TMJ testing	Cranial and spinal CMT	Patient had lost her vision in the right eye 3 weeks previous to treatment. After 1 visit, patient could see 20-30 on Snellen eye chart. Visual acuity 20-13 after 3rd visit and asymptomatic 3 years later.
Meldener (2005)	Post-surgical hip dislocation	1: 75 yoa male	AK MMT to diagnose muscular weakness around hip and throughout the body	AK and CMT therapy, focusing on the connection of the TMJ and occlusion to instability of the hip.	No hip dislocation since vertical dimension was increased with new upper dentures on doctor's recommendation.
Chung et al (2005)	Dental occlusion position problems	7: male 3: female	AK MMT during application of an oral dental appliance	None	AK MMT reliable and repeatable on different days. MMT useful to locate the kinesiologic occlusal position for the fabrication of an oral appliance to treat TMJ disorders.
Caso (2004)	Congenital bowel abnormality related to low back pain.	1: 29 yoa male	AK MMT to diagnose large bowel dysfunction	CMT and stimulation of Chapman's reflex points by the doctor and the patient at home.	Resolution of the patient's low back pain as well as improved bowel function.
Moncayo et al (2004)	Thyroid-associated orbitopathy (TAO)	32 patients with TAO, 23 with a long-standing disease, and 9 showing discrete initial changes	Positive TL (patient touches area of dysfunction and weakening occurs on MMT) reactions were found in the submandibular tonsillar structures, the tonsilla pharyngea, the San Yin Jiao point, the lacrimal gland, and with the ocular lock test of AK.	AK treatment and homeopathic remedies	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 improved. Clinical trial of 3—6 months showed all relevant parameters improved.
Cuthbert (2003)	Down syndrome	15 children	Informal report by the parents of child's function and health status.	CMT to the spine and cranium, with nutritional support as needed.	Improved fine motor skills; use of the hands and fingers; ability to crawl bilaterally with arms and legs; ability to stand and walk; decrease in tongue thrusting; problems with ears and sinuses were all improved in function as noted by parents, teachers, and doctor.

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Appendix (*continued*)

Authors, date	Diagnosis	Subject(s)	Repeated Observations	Treatments	Outcomes
Maykel (2003)	Blocked naso-lacrimal canal	1: 14-month male	AK MMT and informal report of child's function and health status by the parents.	CMT to the spine and cranium	Child treated 5 times over a 6-week period with resolution of his eye problem.
Weiss (2003)	Menstrual difficulty and exhaustion	1: 39 yoa female	AK MMT and patient report of condition	Nutritional counseling and CMT to the spine and cranium	Treatment to the sacrococcygeal area with cranial correction and nutritional support improved her energy level and cycling performance.
Sprieser (2002)	Episodic paroxysmal vertigo	1: 17 yoa female	AK MMT and patient report of her condition	CMT to the spine and cranium as well as AK/ meridian therapy techniques.	After 4 treatments and 3 other treatments by a Qi-Gong master, the patient remained free of any vertigo at 3 year follow up.
Leaf (2002)	Severe equilibrium problems	1: 48 yoa female	AK MMT and patient report of condition	Cervical traction of 6 pounds while patient walked for 15 min	After cervical traction-distraction-patient was able to stand with her feet together with no body sway and displayed no signs of nystagmus.
Gregory et al. (2001)	Women with moderate to severe breast pain	88: females, predominantly premenopausal, with cyclical and non-cyclical breast pain	Tenderness of neurolymphatic reflexes for the large intestine	Reflex stimulation of neurolymphatic reflex points by the doctor and the patient at home.	Immediately after treatment, there was considerable reduction in breast pain in 60% of patients with complete resolution in 18%. 2 months after initial treatment, there was a reduction in severity, duration and frequency of pain of 50% or more in 60% of cases ($P < .01$).
Cuthbert (2001)	Bell's Palsy	1: female	AK MMT to diagnose cranial, cervical, TMJ, and muscular imbalances	CMT to the spine, TMJ, and cranium	Complete resolution of facial nerve palsy after 6 visits over 14 days.
Calhoon (2001)	Multiple sclerosis	1: 43 yoa female	AK MMT and patient report of condition	CMT to the spine, TMJ, and cranium and nutritional support	26 months after initial visit, patient had regained her ability to write and could shower without assistance for the first time in 2 years.
Mathews et al (1989)**	Learning disabilities	10 children compared with a control group of 10 children matched for age, IQ and social background that had not received any treatment over a similar period.	AK MMT examination and sensory challenges; the children were tested before and after treatment by an Educational Psychologist using standardized tests of intelligence to monitor changes in their learning skills.	AK treatment	Educational psychologist's testing demonstrated children treated with AK had an improvement in their learning abilities during the course of 9—12 treatment sessions during a period of 6—12 months.

Masarsky Weber (1991)	Somatic dyspnea	6: males and females	AK MMT examination methods; forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV-1) measurements pre- and post-treatment (post-treatment measurements taken 3 days later to 1 month later).	AK treatment including neurolymphatic and neurovascular reflexes were employed for the diaphragm muscle; evaluation of the meridian system; cranial manipulation (AK methods); and treatment for inhibited muscles involved in respiration.	All patients reported improvement in their breathing difficulty. 4 of the 6 patients also had improved FCV and FEV-1 between 0.1 and 0.8 L.
Goodheart (1990)	Imbalanced weight bearing on right and left feet	40 patients	40 patients were evaluated for pre- and post-treatment weight balance.	AK examination and treatment	Of the 40 patients, only one had minimal changes in weight upon two scales beneath the feet when both flexing and extending the spine.
Masarsky et al. (1988)	Chronic obstructive pulmonary disease	1: male	AK MMT examination methods; forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV-1) measurements pre- and post-treatment, covering an 8-month period.	AK examination and treatment	Improvements were noted in forced vital capacity, forced expiratory volume in 1 s, coughing, fatigue, and ease of breathing (sign significant at 0.005 level). Improvement was also noted in laryngospasm.
Jacobs et al (1984)	Thyroid dysfunction	65: males and females	Patients evaluated for thyroid dysfunction by AK and laboratory testing	None	AK ratings correlated with laboratory ratings ($r_s = 0.32$, $p < .002$) and with laboratory ratings ($r_s = 0.32$, $p < .005$). Correlation between clinical and laboratory diagnosis was 0.47, $p < .000$. 3 AK therapy localizations had a significant correlation with the laboratory diagnosis ($p < .05$). AK enhanced but did not replace clinical/laboratory diagnosis of thyroid dysfunction. Evidence indicated a significant correlation between certain AK tests and an elevated LDH in the serum.

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