

Can ankle imbalance be a risk factor for tensor fascia lata muscle weakness? Zampagni ML, Corazza I, Molgora AP, Marcacci M.

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Abstract: Risk factors that can determine knee and ankle injuries have been investigated and causes are probably multifactorial. A possible explanation could be related by the temporary inhibition of muscular control following an alteration of proprioceptive regulation due to the ankle imbalance pathology. The purpose of our study was to validate a new experimental set up to quantify two kinesiologic procedures (**Shock Absorber Test (SAT) and Kendall and Kendall's Procedure (KKP)**) to verify if a subtalus stimulus in an ankle with imbalance can induce a non-appropriate response of controlateral tensor fascia lata muscle (TFL). Fifteen male soccer players with ankle imbalance (AIG) and 14 healthy (CG) were tested after (TEST) before (NO-TEST) a manual percussion in subtalus joint (SAT). A new tailor-made device equipped with a load cell was used to quantify TFL's strength activation in standardized positions. Two trials for each subject were performed, separated by at least one 4-min resting interval. In NO-TEST conditions both AIG and CG showed a progressive adaptation of the subject to the force imposed by operator. No reduction in mean force, mean peak force, and muscle force duration ($p>0.5$). AIG presented significant differences (mean difference 0.92 ± 0.46 s; $p=0.000$) in muscle force duration in TEST conditions. **Our results indicated that "wrong" proprioceptive stimuli coming from the subtalus joint in AIG might induce inhibition in terms of duration of TFL muscle altering the knee stability. This kinesiological evaluation might be useful to prevent ankle and knee injuries.**

Comment: This fascinating study investigates two fundamental procedures developed in AK over 25 years ago. This research report (conducted by physical therapists and medical doctors in Italy) specifically cites AK as the source for the information in this study. The "shock absorber test" developed in AK is a screening examination for extended foot pronation, subluxations, and other dysfunctions of the foot. When there is foot dysfunction, quite often after striking the foot with many vectors, a previously strong indicator muscle will test weak. This was demonstrated in this controlled clinical trial. In the earlier days of applied kinesiology, Goodheart reported that Edward Doss, Sr., D.C., of Stuttgart, Arkansas, told him of his frequent observation that a lateral cuboid subluxation correlated with a tensor fascia lata muscle that tested weak. Correction of the subluxation returned normal function to the muscle as observed by manual muscle testing. Goodheart concurred with the observation, and also found that adjusting the medial transverse arch (medial cuboid) often corrected adductor muscles that tested weak.

Comparison of four tests of quadriceps strength in L3 or L4 radiculopathies, Rainville J, Jouve C, Finno M, Limke J.

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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

	<p>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.</p>
<p>The ability of male and female clinicians to effectively test knee extension strength using manual muscle testing, Mulroy SJ, Lassen KD, Chambers SH, Perry J.</p>	<p><i>J Orthop Sports Phys Ther.</i> 1997 Oct;26(4):192-9.</p> <p>Abstract: It has been suggested that the accuracy of manual muscle testing is dependent on examiner strength. Our purpose was to relate male and female clinicians' upper extremity strength to their ability to challenge the quadriceps and detect weakness in patients using manual muscle testing. Quadriceps muscles of seven men and 12 women with postpoliomyelitis were tested manually by a male and female clinician while forces were recorded with a hand-held dynamometer. Patients' maximal isometric knee extension force was recorded with a Lido dynamometer and clinicians' maximal vertical push force was recorded with the hand-held dynamometer. Manual muscle testing forces, patient maximum quadriceps forces, and examiner push forces were compared with repeated measures analysis of variance. Female examiners' maximal vertical push force (235.7 +/- 54.3 N) was not significantly different from either female or male patients' maximal quadriceps force (166.8 +/- 66.7 N and 341.6 +/- 123.7 N) but was only 60% and 40% of the isometric knee extension forces generated by a group of normal women and men. Male examiners were significantly stronger (357.0 +/- 93.4 N) than the female but not the male patients and produced 90% and 60% of the normal isometric quadriceps forces for women and men. Examiners gave appropriate grades in 30 of 38 tests. Examiner strength limits detection of moderate quadriceps weakness with manual resistance. Most of the muscle test grades, however, were appropriate, given the examiner's upper extremity strength. Clinicians using manual muscle testing should determine their maximal vertical push force and the extent of weakness they can detect.</p>

The reliability of isometric strength and fatigue measures in patients with knee osteoarthritis. McCarthy CJ, Callaghan MJ, Oldham JA.

Man Ther. 2008 May;13(2):159-64. Epub 2007 Feb 12.

Abstract: Patients with knee osteoarthritis have both poor strength and endurance of their quadriceps muscles. It is possible to assess muscle fatigue by monitoring frequency spectrum using electromyography (EMG). This study used the closed kinetic chain approach to muscle assessment. Fifty-five subjects with knee osteoarthritis were examined twice within 1 week. To test maximum voluntary isometric contraction into extension an isokinetic dynamometer, with a closed kinetic chain "leg press" attachment was used. EMG assessment of signal median frequency was done by measuring median frequency shift associated with fatiguing of muscle during a 60s isometric contraction at 60% of maximum isometric contraction. Intra-class correlation coefficients with 95% confidence intervals, standard errors of measurement and smallest detectable differences were calculated. Results showed the reliability of the maximum voluntary isometric contraction extension strength test was ICC 0.99 and SEM 3.95Nm. The initial median frequency indices also demonstrated excellent ICC and SEM statistics (ICC 0.84-0.91, SEM 9.2-11Hz) for the three heads of the quadriceps; however, the fatigue slopes for all three muscles were unreliable with poor ICCs (0.04-0.72) and SDD values (2207-4000%). The assessment of peak muscle torque using a closed kinetic chain isometric technique is reliable, as is the determination of median frequency values for the quadriceps. Error for the assessment of fatigue was of an unacceptable scale. While the use of a closed kinetic chain leg press technique provides a reliable measurement of lower limb strength, EMG power spectrum decrease during an isometric contraction is of little value.

Deficits in neuromuscular control of the trunk predict knee injury risk: a prospective biomechanical-epidemiologic study. Zazulak BT, Hewett TE, Reeves NP, Goldberg B, Cholewicki J.

Am J Sports Med. 2007 Jul;35(7):1123-30. Epub 2007 Apr 27.

BACKGROUND: Female athletes are at significantly greater risk of anterior cruciate ligament (ACL) injury than male athletes in the same high-risk sports. Decreased trunk (core) neuromuscular control may compromise dynamic knee stability. **HYPOTHESES:** (1) Increased trunk displacement after sudden force release would be associated with increased knee injury risk; (2) coronal (lateral), not sagittal, plane displacement would be the strongest predictor of knee ligament injury; (3) logistic regression of factors related to core stability would accurately predict knee, ligament, and ACL injury risk; and (4) the predictive value of these models would differ between genders. **STUDY DESIGN:** Cohort study (prognosis); Level of evidence, 2. **METHODS:** In this study, 277 collegiate athletes (140 female and 137 male) were prospectively tested for trunk displacement after a sudden force release. Analysis of variance and multivariate logistic regression identified predictors of risk in athletes who sustained knee injury. **RESULTS:** Twenty-five athletes (11 female and 14 male) sustained knee injuries over a 3-year period. Trunk displacement was greater in athletes with knee, ligament, and ACL injuries than in uninjured athletes ($P < .05$). Lateral displacement was the strongest predictor of ligament injury ($P = .009$). A logistic regression model, consisting of trunk displacements, proprioception, and history of low back pain, predicted knee ligament injury with 91% sensitivity and 68% specificity ($P = .001$). This model predicted knee, ligament, and ACL injury risk in female athletes with 84%, 89%, and 91% accuracy, but only history of low back pain was a significant predictor of knee ligament injury risk in male athletes. **CONCLUSIONS:** Factors related to core stability predicted risk of athletic knee, ligament, and ACL injuries with high sensitivity and moderate specificity in female, but not male, athletes.

Comment: In AK it has been found that the presence of muscular imbalance and joint dysfunction will alter the ability of the patient to perform stereotypic movement patterns. This paper demonstrates the common and strong correlation between muscle dysfunction and joint dysfunction, a primary thesis of the AK approach. To remain upright and steady in their surroundings, people use all the information about their position provided by their sensory organs in relation to their surroundings. The eyes, the vestibular apparatus, the proprioceptors in muscles and joints all maintain the trunk in proper position when working properly. In this paper, the prevention of joint fatigue and wear and sprain in the knee depends upon the precise integration of sensory information and motor response and strength from the periphery to the trunk.

<p>Effects of anterior cruciate ligament (ACL) injury on muscle activity of head, neck and trunk muscles: a cross-sectional evaluation. Tecco S, Salini V, Teté S, Festa F.</p>	<p><i>Cranio</i>. 2007 Jul;25(3):177-85.</p> <p>Abstract: This study evaluated the effects a pathology of the knee, due to an anterior cruciate ligament (ACL) injury, has on muscular activity of neck, head, and trunk muscles. Twenty-five (25) subjects (mean age 28+/-9 years) with ACL injury of the left knee were compared with a control no-pathology group. Surface electromyography (sEMG) at mandibular rest position and maximal voluntary clenching (MVC) was used to evaluate muscular activity of the areas: masseter, anterior temporalis, posterior cervicals, sternocleidomastoid (SCM), and upper and lower trapezius. The sEMG activity of each muscle, as well as the asymmetry index between the right and the left sides, were compared between the two groups. Subjects in the study group showed a significant increase in the asymmetry index of the sEMG activity of the anterior temporalis at mandibular rest position ($p<0.05$). At rest, the areas of anterior temporalis and masseter in the control group showed a significantly lower sEMG activity compared with subjects in the study group, both in the right and the left sides ($p<0.05$). The same was found for the sEMG activity of the areas of SCM and lower trapezius. At MVC, the right areas of anterior temporalis and masseter in the study subjects showed a significantly lower sEMG activity compared with the control group. The same was observed for the lower trapezius area, both in the right and the left sides. In general, ACL injury appears to provide a change in the sEMG activity of head, neck and trunk muscles.</p> <p>Comment: The most common pain generators are likely to be those structures housing the most nociceptors (articular surfaces, joint capsules, ligaments). Regardless of what is the exact pain generator, the entire motor system will react and compensate. Long after strained soft tissues have been injured, adaptive patterns will persist. One of the great advantages of AK is for the ability to specifically “challenge” the body itself to discover where these maladaptations and reactions are occurring.</p>
<p>A method for comparing manual muscle strength measurements with joint moments during walking, Fosang A, Baker R.</p>	<p><i>Gait Posture</i>. 2006 Dec;24(4):406-11. Epub 2006 Jan 18.</p> <p>Abstract: This paper describes a protocol for dynamometer assisted manual muscle testing of the major muscle groups of the lower extremity and its application to 11 able-bodied children who also had conventional gait analysis to obtain joint kinetics. Data from the manual muscle testing was processed in such a way that the results for maximum muscle strength (grade 5) and resistance against gravity alone (grade 3) were presented in Nm/kg allowing direct comparison with conventional joint kinetics. The strength measurements of the hip muscles and the knee extensors were between two and three times the moments exerted during normal walking. Those of the knee flexors and dorsiflexors were about five times the joint moments. Measured plantarflexor strength was only just greater than the moment exerted during walking. These results, particularly those for the plantarflexors, question how valid it is to use measures of isometric muscle strength as indicators of muscle function during activity. The study also compares grade 3 muscle strength with both grade 5 strength and the maximum joint moments. For all muscle groups tested grade 3 muscle strength was less than the maximum moment exerted during normal walking. For the plantarflexors it was less than 1% of that moment. The study demonstrates that reliable isometric muscle testing is possible in able-bodied children but requires considerable care and is time consuming. More work is required to understand how measurements made in this way relate to how muscles function during activity.</p> <p>Comment: Many studies have compared the findings of MMT with dynamometer tests favorably, however dynamometers are not as sensitive to changes in strength nor to strength measurements below 3 during the MMT. The human examiner is the most sensitive of all instruments in relationship to interpreting the MMT.</p>
<p>A pilot study comparing the effects of spinal manipulative therapy with those of extra-spinal manipulative therapy</p>	<p><i>J Manipulative Physiol Ther</i>, 2006 Feb;29(2):145-9.</p> <p>OBJECTIVE: The objective of this study was to assess whether tibiofemoral joint manipulation is as effective as sacroiliac (SI) joint manipulation in increasing quadriceps muscle strength.</p> <p>DESIGN AND SETTING: Twenty subjects were divided into two groups of 10. After all base</p>

<p>on quadriceps muscle strength, Hillermann B, Gomes AN, Korporaal C, Jackson D.</p>	<p>measurements of the maximum voluntary force of the quadriceps muscles were taken, subjects in group A received tibiofemoral joint manipulation and those in group B received ipsilateral SI joint manipulation. After these treatments, the maximum voluntary forces of the subjects' quadriceps muscles were retested. RESULTS: A significant improvement ($P = .05$) in quadriceps muscle strength was noted in the subjects who received an SI joint manipulation. CONCLUSION: This study showed a significant change within the SI joint manipulation group before and after the manipulation but did not show any significant difference between the groups (tibiofemoral joint vs. SI joint manipulation) in increasing quadriceps muscle strength. Comment: This study demonstrates that an immediately measurable change in muscle strength, from inhibition to strength, occurs after SI joint manipulation. A weakness in this study's design is that the manipulation of the tibiofemoral joint was a long-axis manipulation of the joint. There was no evaluation done as to whether this joint had any mechanical problem or subluxation present within it. A more specific design would have been to compose group B of subjects who had knee pain in the area of the tibiofemoral joint. Better yet would have been to find subjects for group B who had specific dysfunctions of the tibiofemoral joint. After manipulating the subluxated tibiofemoral joint into proper position, an evaluation of the inhibited quadriceps muscle might have found an improvement in its strength upon testing. In AK, adjustment of the articulations of the knee frequently improves the function of the quadriceps muscle, as does adjustment of the SI joint when it is subluxated.</p>
<p>Motor unit synchronization is reduced in anterior knee pain, Mellor R, Hodges PW.</p>	<p><i>J Pain.</i> 2005 Aug;6(8):550-8.</p> <p>Abstract: Anterior knee pain (AKP) is common and has been argued to be related to poor patellofemoral joint control due to impaired coordination of the vasti muscles. However, there are conflicting data. Changes in motor unit firing may provide more definitive evidence. Synchronization of motor unit action potentials (MUAPs) in vastus medialis obliquus (VMO) and vastus lateralis (VL) may contribute to coordination in patellofemoral joint control. We hypothesized that synchronization may be reduced in AKP. Recordings of single MUAPs were made from VMO and multiunit electromyograph (EMG) recordings were made from VL. Averages of VL EMG recordings were triggered from the single MUAPs in VMO. Motor units in VL firing in association with the VMO motor units would appear as a peak in the VL EMG average. Data were compared to previous normative data. The proportion of trials in which a peak was identified in the triggered averages of VL EMG was reduced in people with AKP (38%) compared to controls (90%). Notably, although 80% of subjects had values less than controls, 20% were within normal limits. These results provide new evidence that motor unit synchronization is modified in the presence of pain and provide evidence for motor control dysfunction in AKP. PERSPECTIVE: This study shows that coordination of motor units between the medial and lateral vasti muscles in people with anterior knee pain is reduced compared to people without knee pain. It confirms that motor control dysfunction is a factor in this condition and has implications for selection of rehabilitation strategies. Comment: This study suggests that in some cases, correcting knee pain is often as simple as correcting the muscles that stabilize the knee. AK evaluation of knee dysfunction always involves testing the knee-supporting muscles' function.</p>
<p>Hip strength in females with and without patellofemoral pain. Ireland ML, Willson JD, Ballantyne BT, Davis IM.</p>	<p><i>J Orthop Sports Phys Ther.</i> 2003 Nov;33(11):671-6.</p> <p>STUDY DESIGN: Cross-sectional. OBJECTIVES: To determine if females with anterior knee pain are more likely to demonstrate hip abduction or external rotation weakness than a similar, asymptomatic, age-matched control group. BACKGROUND: Diminished hip strength has been implicated as being contributory to lower-extremity malalignment and patellofemoral pain. The identification of reliable and consistent patterns of weakness in this population may assist health care professionals establish a more effective treatment plan. METHODS AND MEASURES: Hip abduction and external rotation isometric strength measurements were recorded for the injured side of 15 female subjects with patellofemoral joint pain (mean +/- SD age, 15.7 +/- 2.7 years; age range, 12-21 years). These were compared with strength measurements from the</p>

	<p>corresponding hip of 15 age-matched female control subjects (mean +/- SD age, 15.7 +/- 2.7 years; age range, 12-21 years). All strength measurements were made using hand-held dynamometers. RESULTS: Subjects with patellofemoral pain demonstrated 26% less hip abduction strength ($P < .001$) and 36% less hip external rotation strength ($P < .001$) than similar age-matched controls. CONCLUSIONS: The results indicate that young women with patellofemoral pain are more likely to demonstrate weakness in hip abduction as well as external rotation than age-matched women who are not symptomatic.</p> <p>Comment: A key factor in the successful treatment of patients with knee pain is the detection and correction of muscle weakness.</p>
<p>Management of patellofemoral pain targeting hip, pelvis, and trunk muscle function: 2 case reports. Mascal CL, Landel R, Powers C.</p>	<p><i>J Orthop Sports Phys Ther.</i> 2003 Nov;33(11):647-60.</p> <p>STUDY DESIGN: Case report. OBJECTIVE: To describe an alternative treatment approach for patellofemoral pain. BACKGROUND: Weakness of the hip, pelvis, and trunk musculature has been hypothesized to influence lower-limb alignment and contribute to patellofemoral pain. Two patients who had a chief complaint of patellofemoral pain and demonstrated lack of control of the hip in the frontal and transverse planes during functional movements were treated with an exercise program targeting the hip, pelvis, and trunk musculature. METHODS AND MEASURES: The patients presented in these 2 case reports did not exhibit obvious patellar malalignment or tracking problems; however, on qualitative assessment, both demonstrated excessive hip adduction, internal rotation, and knee valgus during gait and while performing a step-down maneuver. In addition, both patients exhibited weakness of the hip abductors, extensors, and external rotators, as demonstrated by hand-held dynamometry testing. Treatment in both cases occurred over a 14-week period and focused on recruitment and endurance training of the hip, pelvis, and trunk musculature. Functional status, pain, muscle force production, as well as subjective and objective assessment of lower-extremity kinematics during gait and a step-down maneuver were assessed preintervention and postintervention. RESULTS: Both patients experienced a significant reduction in patellofemoral pain, improved lower-extremity kinematics during dynamic testing, and were able to return to their original levels of function. Gluteus medius force production improved by 50% in patient A and 90% in patient B, while gluteus maximus force production improved 55% in patient A and 110% in patient B. Objective kinematic improvements in the step-down task also were demonstrated in patient A. CONCLUSION: Assessment and treatment of the hip, pelvis, and trunk musculature should be considered in the rehabilitation of patients who present with patellofemoral pain and demonstrate abnormal lower-extremity kinematics.</p>
<p>Measuring knee extensor muscle strength, Bohannon RW.</p> <p>-- Department of Physical Therapy, School of Allied Health, University of Connecticut, Storrs 06269-2101, USA.</p>	<p><i>Am J Phys Med Rehabil.</i> 2001 Jan;80(1):13-8.</p> <p>OBJECTIVE: To compare manual muscle test with hand-held dynamometer measurements of knee extension strength. A secondary analysis of measurements ($n = 256$ knees) from 128 acute rehabilitation patients was performed. DESIGN: Knee extensor muscle testing was conducted according to the technique of Hislop and Montgomery; 0 to 5 grades were converted to an expanded 0 to 12 scale. Dynamometry was used to measure the isometric knee extension force with 'gravity eliminated.' RESULTS: Manual muscle test and dynamometer measures were highly correlated ($r = 0.768$; $P < 0.001$); the correlation was higher when the quadratic nature of the relationship was taken into account ($R = 0.887$; $P < 0.001$). Although the dynamometer forces that were associated with different manual muscle test grades differed overall ($F = 67.736$; $P < 0.001$), the forces associated with some of the higher grades did not differ statistically. CONCLUSIONS: These findings reinforce the convergent construct validity of the manual muscle test and dynamometry measurements but challenge the discriminant construct validity of manual muscle testing. An alternative manual muscle testing grading scheme is suggested that provides for discriminant validity and retains convergent validity.</p>
<p>Effect of knee joint effusion</p>	<p><i>Med Sci Sports Exerc.</i> 2001 Jan;33(1):123-6.</p>

<p>on quadriceps and soleus motoneuron pool excitability, Hopkins JT, Ingersoll CD, Krause BA, Edwards JE, Cordova ML.</p>	<p>PURPOSE: To examine changes in quadriceps and soleus MN pool activity resulting from knee joint effusion over a 4-h period and assess the relationship between the muscles. METHODS: A repeated measures before-after trial design was used for this study. Eight, neurologically sound volunteers (age 23.3+/-2.1 yr, height 171.8+/-15.9 cm, mass 65.5+/-17.7 kg) participated in this study. An area superomedial to the patella was cleaned and anesthetized, and 30 mL of sterile saline was injected into the knee joint capsule to mimic mechanical joint effusion. The Hoffman reflex (H-reflex) was elicited by applying a percutaneous stimulus to the appropriate nerve and recording the response through surface electromyography. Soleus and vastus medialis H-reflex measures were collected from each volunteer before, at 30 min, 90 min, 150 min, and 210 min intervals over a 4-h period after knee effusion. RESULTS: All soleus H-reflex measures after effusion (30 min 5.89+/-0.92 V; 90 min 6.16+/-0.48 V; 150 min 6.59+/-0.50 V; 210 min 6.70+/-0.56 V) were increased in relation to the preeffusion measure (5.01+/-0.79 V). All vastus medialis H-reflex measures after effusion (30 min 4.23+/-0.94 V; 90 min 4.15 +/-1.11 V; 150 min 4.16+/-0.57 V; and 210 min 4.99+/-1.23) were decreased in relation to the preeffusion measure (5.88+/-1.44 V; P < or = 0.05). CONCLUSIONS: Afferent activity from the knee joint capsule resulted in an inhibitory effect on the vastus medialis and a facilitatory effect on the soleus. Facilitation of the soleus in cooperation with other lower extremity musculature could be a mechanism for compensation of the inhibited quadriceps to maintain lower kinetic chain function.</p>
<p>Conservative lower back treatment reduces inhibition in knee-extensor muscles: a randomized controlled trial, Suter, E., McMorland, G., Herzog, W., Bray, R.</p>	<p><i>J Manipulative Physiol Ther</i>, 2000;23:76-80</p> <p>(http://www.journals.elsevierhealth.com/periodicals/yymt/article/PIIS016147540090071X/abstract)</p> <p>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 <i>muscle inhibition</i> (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 SI-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.</p>
<p>Decrease in quadriceps inhibition after sacroiliac</p>	<p><i>J Manipulative Physiol Ther</i>, 1999;22:149-153</p>

joint manipulation in patients with anterior knee pain, Suter, E., McMorland G, Herzog W, Bray R.

<http://www.journals.elsevierhealth.com/periodicals/yjmt/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.

Quadriceps weakness and osteoarthritis of the knee. Slemenda C, Brandt KD, Heilman DK, Mazzuca S, Braunstein EM, Katz BP, Wolinsky FD.

Ann Intern Med. 1997 Jul 15;127(2):97-104.

BACKGROUND: The quadriceps weakness commonly associated with osteoarthritis of the knee is widely believed to result from disuse atrophy secondary to pain in the involved joint. **However, quadriceps weakness may be an etiologic factor in the development of osteoarthritis.** **OBJECTIVE:** To explore the relation between lower-extremity weakness and osteoarthritis of the knee. **DESIGN:** Cross-sectional prevalence study. **SETTING:** Population-based, with recruitment by random-digit dialing. **PARTICIPANTS:** 462 volunteers 65 years of age or older. **MEASUREMENTS:** Radiographs of the knee were graded for the presence of osteoarthritis. Knee pain and function were assessed with the Western Ontario and McMaster Universities Arthritis Index, the strength of leg flexors and extensors was assessed with isokinetic dynamometry, and lower-extremity lean tissue mass was assessed with dual-energy x-ray absorptiometry. **RESULTS: Among participants with osteoarthritis, quadriceps weakness, but not hamstring weakness, was common. The ratio of extensor strength to body weight was approximately 20% lower in those with than in those without radiographic osteoarthritis. Notably, among women with tibiofemoral osteoarthritis, extensor weakness was present in the absence of knee pain and was seen in participants with normal lower-extremity lean mass (extensor strength, 30.1 lb-ft for those with osteoarthritis and 34.8 lb-ft for those without osteoarthritis; *P* < 0.001). After adjustment for body weight, age, and sex, lesser quadriceps strength remained predictive of both radiographic and symptomatic osteoarthritis of the knee (odds ratio for prevalence of osteoarthritis per 10 lb-ft loss of strength, 0.8 [95% CI, 0.71 to 0.90] for radiographic osteoarthritis and 0.71 [CI, 0.51 to 0.87] for symptomatic osteoarthritis). **CONCLUSION: Quadriceps weakness may be present in patients who have osteoarthritis but do not have knee pain or muscle atrophy; this suggests that the weakness may be due to muscle****

	<p>dysfunction. The data are consistent with the possibility that quadriceps weakness is a primary risk factor for knee pain, disability, and progression of joint damage in persons with osteoarthritis of the knee.</p> <p>Comment: This study is very important and suggests that the validity of MMT in cases of knee pain and osteoarthritis is sound. In this study, quadriceps muscle weakness preceded osteoarthritis of the knee and may be pathogenic. They state that quadriceps action serves as a brake, retarding the rate of the descent of the leg at the end of the swing phase of gait. Quadriceps weakness could accelerate damage to articular cartilage in the knee. Patients with painless osteoarthritis that may appear on X-ray probably should be tested for muscle weakness and given treatment to correct this as prevention. At the very least, everyone with knee pain should have their quadriceps muscles tested for strength.</p>
<p>Reduced muscle function in patients with osteoarthritis, Fisher NM, Pendergast DR.</p> <p>-- Department of Rehabilitation Medicine, State University of New York at Buffalo, USA.</p>	<p><i>Scand J Rehabil Med.</i>1997 Dec;29(4):213-21</p> <p>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.</p>
<p>Muscle inhibition following knee injury and disease, Herzog W, Suter E.</p>	<p><i>Sportverletz Sportschaden,</i> 1997 Sep;11(3):74-8.</p> <p>Abstract: It has been observed that knee extensor muscles cannot be fully activated during voluntary contractions following knee injuries. This muscle inhibition has an unknown origin and appears to hinder full rehabilitation of the affected joint. We have investigated muscle inhibition during and following knee injuries in non-athletic and athletic patients and compared their results to non-athletic, unaffected volunteer subjects. There appears to be a small amount of muscle inhibition in the knee extensors of normal subjects; this inhibition increases dramatically following knee injury, and appears to go back to normal levels following surgical intervention, aggressive physiotherapy, or a sufficient amount of time. Depending on the intervention, strength deficits of the affected compared to the unaffected knee extensor muscles may persist. Aggressive physiotherapy can eliminate strength deficits following knee injury through an increased ability to recruit the knee extensors in patients more completely compared to normal subjects.</p> <p>Comment: The correlation between joint injury to the knee and muscle inhibition found upon muscle testing is very clearly described here. This is a central tenet of AK, i.e. that joint injuries will produce muscle weakness that can be specifically diagnosed and treated. On a clinical basis, AK physicians find this consistently when testing patients with knee injuries. Manual therapy is shown in this paper to improve the strength of muscles supporting the knee, and led to an improvement in function and a decrease in pain for these patients.</p>
<p>Muscle function and gait in patients with knee osteoarthritis before and after muscle rehabilitation, Fisher NM, White SC, Smolinski RJ, Pendergast DR.</p>	<p><i>Disabil and Rehabil.</i>1997 Feb;19(2):47-55.</p> <p>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</p>

	<p>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.</p>
<p>Arthrogenic quadriceps inhibition and rehabilitation of patients with extensive traumatic knee injuries, Hurley M, Jones D, Newham D</p>	<p><i>Clin Sci (Lond)</i>. 1994 Mar;86(3):305-10.</p> <p>Abstract: 1. The relationship between joint damage, quadriceps weakness and arthrogenic muscle inhibition was investigated in eight patients who had sustained extensive traumatic knee injury. Isometric and isokinetic quadriceps and hamstring voluntary strength, and quadriceps arthrogenic muscle inhibition during isometric contractions, were measured before and after 4 weeks (approximately 100 h) of intensive rehabilitation. 2. Compared with the uninjured leg, before rehabilitation the injured leg had larger amounts of quadriceps arthrogenic muscle inhibition ($P < 0.025$), quadriceps ($P < 0.0001$) and hamstring ($P < 0.0001$) weakness and severe functional joint instability. There was a negative correlation between the amount of arthrogenic muscle inhibition and quadriceps voluntary contraction force ($P < 0.025$). 3. After rehabilitation in the injured leg there were small hamstring strength increases ($P < 0.05-0.025$), but no overall significant quadriceps strength increase. Arthrogenic muscle inhibition was statistically unchanged. Severe functional joint instability was still reported by all patients. 4. Previous studies have shown that minimal joint damage evokes relatively less arthrogenic muscle inhibition that does not impede rehabilitation. These data indicate that greater joint damage is associated with greater arthrogenic muscle inhibition, quadriceps weakness and joint instability. Furthermore, intensive rehabilitation had little effect on either quadriceps arthrogenic muscle inhibition or atrophy.</p> <p>Comment: This study indicates that specific injuries to the knee joint produce measurable inhibitions of quadriceps and hamstring muscles. This is a central tenet of AK, i.e. that joint injuries will produce muscle weakness that can be specifically diagnosed and treated. On a clinical basis, AK physicians find this consistently when testing patients with knee injuries. The fact that rehabilitation did not improve the arthrogenic inhibition found in these patients may indicate that the totality of their joint and muscle problems in the knee was not adequately treated.</p>
<p>The influence of arthrogenous muscle inhibition on quadriceps rehabilitation of patients with early, unilateral osteoarthritic knees, Hurley MV, Newham DJ.</p>	<p><i>Br J Rheumatol</i>, 1993 Feb;32(2):127-31.</p> <p>Abstract: Reflex arthrogenous muscle inhibition (AMI) may cause muscle atrophy or impede effective rehabilitation of affected muscle groups. To investigate this, bilateral quadriceps AMI, isometric and isokinetic muscle strength were measured in 10 patients with unilateral osteoarthritic knees, before and after a course of routine physiotherapy. Before rehabilitation, quadriceps of all the diseased legs were inhibited ($P < 0.05$) and 40% weaker ($P < 0.02$) than the non-diseased legs. Following rehabilitation, AMI decreased ($P < 0.01$) in the diseased leg and strength increased at all test velocities ($P < 0.05-0.005$); however, strength deficits compared with the non-diseased leg remained. Subjective improvements in functional ability and confidence in the diseased leg were reported. Though AMI may be partially responsible for unilateral muscle weakness, it does not preclude strength gain in affected muscles. Possible physiological mechanisms which evoke AMI may also adversely affect muscle proprioception, implicating AMI as a possible cause of initiation or progression of degenerative joint disease.</p> <p>Comment: This study demonstrates that being able to reduce arthrogenous muscle inhibition in patients recovering from joint injuries is important to the rehabilitation process. It also shows that a measurable change in muscle strength, from inhibition to strength, occurs after manipulative therapy. AMI is the inability of a muscle to recruit all motor units of a muscle group during a maximal effort voluntary muscle contraction and it is a natural response designed to protect joints from further damage. The AMI phenomenon is frequently found during AK evaluations</p>

	<p>when there is muscle weakness around joints that have been injured. Mechanoreceptor activity plays a primary role in AMI. Manipulation of a joint has been shown to activate mechanoreceptors from structures in and around the manipulated joint. The altered afferent input arising from the stimulation of these receptors is thought to cause changes in motor neuron excitability, with a subsequent decrease in AMI. This is assumed to influence motor neuron pool recruitment during voluntary muscle contraction.</p>
<p>Determinants of disability in osteoarthritis of the knee, McAlindon TE, Cooper C, Kirwan JR, Dieppe PA.</p>	<p><i>Ann Rheum Dis.</i> 1993 Apr;52(4):258-62.</p> <p>OBJECTIVES: To evaluate the influences of radiographic severity, quadriceps strength, knee pain, age, and gender on functional ability in patients with osteoarthritis of the knee. METHODS: Equal numbers of knee pain positive and negative respondents to a survey of registrants aged more than 55 years at a general practice were invited to attend for knee radiographs and quadriceps femoris isometric strength estimations. Disability was measured using the Stanford Health Assessment Questionnaire. RESULTS: Complete data were available on 70 men (mean age 72.7 years) and 89 women (mean age 68.1 years); 44% reported knee pain, 48% had radiographic features of osteoarthritis, and 32% reported some degree of disability. Significant correlations were observed between disability and radiographic score, quadriceps strength, and knee pain. Logistic regression analysis, however, showed significant independent contributions from quadriceps strength (odds ratio 0.84 kgF), knee pain (odds ratio 1.67), and age (odds ratio 1.06 per year) only; the radiographic score had no influence on the model. These results were not influenced by confining the analysis to the group with radiographic features of osteoarthritis. CONCLUSIONS: Quadriceps strength, knee pain, and age are more important determinants of functional impairment in elderly subjects than the severity of knee osteoarthritis as assessed radiographically. <u>Strategies designed to optimise muscle strength may have the potential to reduce a vast burden of disability, dependency, and cost.</u></p>
<p>Effects of joint pathology on muscle, Young A, Stokes M, Iles JF.</p>	<p><i>Clin Orthop Relat Res,</i> 1987 Jun;(219):21-7.</p> <p>Abstract: The muscle wasting associated with joint damage may be highly selective; knee disorders produce quadriceps wasting but little change in the size of the hamstrings. This causes isolated quadriceps weakness, so predisposing to a position of knee flexion. Nociceptors and other receptors in and around the joint can have flexor excitatory and extensor inhibitory actions. At the knee, these receptors are likely to excite hamstrings and inhibit quadriceps. Although other actions could occur, quadriceps inhibition may be favored by a position of knee extension. Quadriceps inhibition will weaken voluntary contraction, reduce tone, and contribute to wasting of the muscle, further predisposing to a position of knee flexion. The potency of quadriceps inhibition may be considerable, even in the absence of perceived pain. A small, apparently trivial effusion (or even a clinically undetectable effusion) may cause important inhibition. In order to improve the orthopedist's ability to prevent flexion contracture of the injured or operated joint, he must look not only for ways of reducing joint pain, but also for ways of preventing activity in other joint afferents. For example, he must consider the possible effects of joint position, intraarticular pressure, suture-line tension, and afferent blockade.</p> <p>Comment: This study demonstrates that structural alterations in the knee joints produce immediate and measurable weaknesses in the muscles that support and stabilize the knee. If the muscles at the front of the knee (quadriceps) are weak, this may produce joint instability and perpetuate the knee joint dysfunction until corrected.</p>
<p>The relationship of knee and ankle weakness to falls in nursing home residents, Whipple, R, Wolfson, L, Amerman, P.</p>	<p><i>J Am Geriatr Soc,</i> 1987;35:329-32</p> <p>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</p>

	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.
The relationship of injuries of the leg, foot, and ankle to proximal thigh strength in athletes, Nicholas JA, Marino M.	<p><i>Foot Ankle.</i> 1987 Feb;7(4):218-28</p> <p>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.</p> <p>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.</p>
Manual muscle test scores and dynamometer test scores of knee extension strength, Bohannon RW.	<p><i>Arch Phys Med Rehabil.</i> 1986 Jun;67(6):390-2.</p> <p>The knee extension force of 50 patients was investigated using traditional manual muscle testing and hand-held dynamometry. The relationship between manual muscle test word scores and dynamometer force scores was determined using Kendall tau, as was the relationship between manual muscle test percentage scores and dynamometer scores expressed as a percentage of "normal." Percentage scores were also compared to determine if a significant difference existed. Manual muscle test scores and dynamometer test scores were significantly correlated (p less than .001). Percentage manual muscle test and dynamometer test scores were significantly different (p less than .001). These results suggest that the two procedures measure the same variable-strength. Manual muscle test percentage scores of knee extension may, however, overestimate the extent to which a patient is "normal."</p>
Reflex inhibition of the quadriceps after meniscectomy: lack of association with pain, Shakespeare DT, Stokes M, Sherman KP, Young A.	<p><i>Clin Physiol.</i> 1985 Apr;5(2):137-44.</p> <p>Abstract: We have examined the severity and duration of reflex inhibition of quadriceps activation after arthrotomy and meniscectomy, its relationship with pain, and the effect of local anesthesia on this relationship. Fourteen men, on completion of medial meniscectomy by arthrotomy, received either 10 ml (B10 group) or 15 ml (B15 group) of 0.5% bupivacaine hydrochloride ('Marcaine Plain') into the knee, or no injection (control group). Reflex inhibition of quadriceps was measured as the percentage reduction, from the ipsilateral preoperative value, in the integrated surface electromyogram recorded during maximal voluntary isometric contractions with the knee in extension. Pain during each contraction was recorded on a linear analogue scale. Unoperated limbs showed no evidence of quadriceps inhibition. In the operated limbs, at 1-2 h post-operatively, controls had both severe inhibition (median = 62%) and severe pain on attempting a maximal quadriceps contraction. The B10 group had similar inhibition but less pain (P less than or equal to 0.005, Wilcoxon 2-sample, 1-tailed test). In the B15 group both inhibition (P less than or equal to 0.05) and pain (P less than or equal to 0.01) were less than in the controls. These effects of bupivacaine had been lost by 4-5 h post-operatively. At 3-4 days, inhibition was still severe (median = 75%) in all three groups of patients but pain was only mild or absent. At 10-15 days, median inhibition was still 35%, but there was little or no pain. We conclude that postmeniscectomy inhibition is not simply due to perceived pain but is due, at least</p>

	in part, to stimuli from the knee.
<p>Knee joint effusion and quadriceps reflex inhibition in man, Spencer JD, Hayes KC, Alexander IJ.</p>	<p><i>Arch Phys Med Rehabil.</i> 1984 Apr;65(4):171-7.</p> <p>Abstract: This study was designed to elucidate the role of effusion in producing the reflex inhibition, and subsequent atrophy, of quadriceps musculature following knee trauma. In particular, consideration was given to determining the extent, threshold and linearity of inhibition of the motoneuron pool induced by experimental introduction of small increments of 0.9% physiological saline (up to 60ml) into the joint space of the knee in ten healthy subjects. Inhibition of the quadriceps muscle motoneuron pool was indirectly assessed through recording Hoffmann (H) reflexes evoked from vastus medialis, lateralis and rectus femoris. All ten subjects showed a significant (p less than 0.05) reduction in H-reflex amplitude following the introduction of saline: vastus medialis reduced to 55.7 +/- 4.3% of its control 0ml value, rectus femoris to 69.1 +/- 6.1% and vastus lateralis to 65.3 +/- 4.0%. Post hoc analyses of the H-reflex amplitudes at each increment of simulated effusion revealed the threshold for reflex inhibition of the vastus medialis to be between 20 and 30ml of saline and for rectus femoris and vastus lateralis to be between 50 and 60ml. These procedures were repeated on eight subjects following an injection of the anesthetic lidocaine (1%) to the intra-articular space of their knee joints but there was no significant reduction in H-reflex amplitude. Linear relationships were found to adequately describe the relationships between the volume of effusion and intra-articular pressure; and volume of effusion and reduction in H-reflex amplitude.</p> <p>Comment: This paper shows that experimentally induced noninflammatory effusions in the knees of 10 human subjects produced a significant reflexly induced inhibition of the alpha-motoneuron pool of the quadriceps muscles in the absence of pain, joint damage, trauma or movement. Furthermore, they state that the reflex inhibition is blocked by intra-articular anesthesia. They conclude that the inhibition is neurologically mediated in response to changes in articular mechanoreceptive input. Altered muscle tone and mobility are consistently found in AK examination in response to changes of articular or periarticular afferent input.</p>