| **Title, authors** | **Year** | **Purpose** | **Intervention** | **Results/Conclusions** | **Clinical Application** |
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| Muscle Control-Pain Control. What Exercises Would You Prescribe?  Richardson, Jull | 1995 | This article describes the specific exercise created by these two authors for treatment of low back pain-the ADIM. | Simultaneous isometric co-contraction of the LM and TA while maintain the spine in a neutral position | This was a descriptive article but the authors concluded this is a specific type of exercise which provides effective pain relief for chronic and recurrent back pain sufferers through enhanced stabilization. Those with CLBP have been found to substitute with global musculature-these patients must be re-trained for automaticity of using the TA and IO for spinal stability during active movements. | * methods of teaching:   + visualization of abs as corset-drawing in around your spine   + verbal cues such as “draw your lower abdomen up and in” or “pull your navel up towards your spine”   + facilitation such as gentle pressure on TA (just medial to ASIS)   + combining with co-contraction of pelvic floor musculature * body positions for re-education: quadruped, prone, upright * eliminate substitutions:   + “sucking in” with rib elevation and/or breath holding   + abnormal bracing using EO (will see depressed rib cage) |
| Persistence Of Improvements In Postural Strategies Following Motor Control Training In People With Recurrent Low Back Pain.  Tsao H, Hodges P | 2008 | To determine if the improvements in feedforward activation of the TA found in subjects with CLBP who underwent training of the isolated contraction of the TA will persist after training has ceased. | Training of isolated contraction of the TA using Richardson’s protocol with ultrasound feedback. Contraction held 10 seconds for 3 sets of 10 contractions with a 2 min rest between sessions. Trained with PT then instructed to do program 2x/day for 4 weeks. | Onset of TA contraction was earlier during rapid arm movement following a single training session (p=.0012), with improvements retained at the 6-month follow-up (p<.001). The co-efficient of variance for TA activation during gait decreased after training and was retained at follow-up (p<.0015). At 6-month follow-up there was a significant reduction in self-reported pain and patient-specific functional scale scores. | * Four weeks of training isolated activation of the TA leads to motor control changes during functional tasks that persist once training has ceased * Changes in motor control may correlate to long term improvement in CLBP |
| Meta-Analysis: Exercise Therapy for Nonspecific Low Back Pain  Hayden J, et al. | 2005 | To assess the effectiveness of exercise therapy for reducing pain and disability in adults with nonspecific acute, subacute, and chronic low back pain compared to no treatment and other conservative treatments. | This article summarizes 61 randomized, controlled trials. Quantitative analysis was performed for pain and function outcomes. Studies that compared several exercise therapy groups were excluded. A qualitative rating system was also used to assess results of primary outcome measures. Studies were classified based on symptom duration: acute (<6 weeks), subacute (6-12 weeks), and chronic (>12 weeks). The definition of “exercise” was not elaborated upon. | * Acute: No significant difference in short-term pain between exercise therapy and no treatment. One low-quality study found an endurance program improved short-term function more than no treatment. * Sub-acute: Evidence is insufficient to support or refute the effectiveness of exercise therapy for reducing pain and improving function. There is moderate evidence from 2 studies for graded-activity exercise programs in occupational settings. * Chronic: There is strong evidence that exercise therapy is at least as effective as other conservative interventions | This study expands the evidence that exercise programs have varying levels of effectiveness in different chronicities of low back pain. This analysis found that improvements in pain and functioning tended to be higher in health care populations. In acute LBP patients, exercise is as effective as either no treatment or other conservative treatments-which is frequently the advice to “stay active.” |
| Low Back Exercises: Evidence for Improving Exercise Regimens  McGill S | 1998 | To provide guidance in exercise prescription for low back patients by investigating common mechanisms of injury and presenting exercises that minimize spinal loading. | EMG signals from the torso are normalized then modulated by known relationships for instantaneous muscle length and velocity of contraction to approximate tissue loading forces during movements. These forces were loaded onto a 3D spinal model to determine at what magnitude and velocity of loading injuries would occur. Swine spines were also used for testing. | * Loading during sit-ups exceeds 3,000 N, with no significant change in force with hips flexed or extended. * Posterior pelvic tilting prior to movement preloads the annulus and posterior ligaments, leading to increased risk of injury. * Endurance has a greater prophylactic and therapeutic value than strength * Prone simultaneous UE/LE ext results in >4,000 N across a hyper-extended spine, resulting in high risk for injury * General recommendations: curl-ups for RA, horizontal side support for quadratus lumborum and obliques, single-leg extension holds in quadruped for extensors, all performed daily. | * At full trunk flexion, spinal support is provided by discs and ligaments, placing spine at high risk for anterior shear injury, and the spine is more susceptible to compressive failure, making stooped lifting a high risk activity. * The spine is most prone to this injury when loads are low so muscles are not highly activated, or when loads are very high. * During upright tasks, co-contraction of the ab musculature provides adequate spinal stability with 2-3% max voluntary contraction. * Exercise prescription must capture all ab muscles-no one exercise does this. * Torso flexibility exercises should be limited to unloaded flexion/ext |
| Exercise And Nonspecific Low Back Pain: A Literature Review.  Henchoz Y, Kai-Lik So A | 2008 | To review the current evidence on the role of exercise in preventing and treating nonspecific low back pain. | Studies were classified based on symptom duration: acute (<6 weeks), subacute (6-12 weeks), and chronic (>12 weeks). The definition of “exercise” was not elaborated. | * Prevention: 7 reviews showed moderate-strong evidence, two with conflicting evidence; 1 review each for strong, moderate, and conflicting evidence for preventing recurrence * Acute: 8 reviews with strong evidence that exercise is not greater than other conservative treatments in reducing pain * Subacute: 3 studies with moderate-strong evidence * Chronic: 6 reviews with strong evidence for decreased pain, disability, secondary deconditioning and time off work; meta-analysis with strong evidence for reduced sick-leave; 2 reviews with moderate strength and 2 with conflicting evidence for exercise greater than placebo; 2 reviews with strong evidence for greater than care of GP | This study also examined general versus specific exercises. Training of localized muscles led to greater decreases in pain and disability at 1 year than physician consultation alone and was better for short term function but fails to significantly improve short-term disability or outcomes at 6-12 months. Combing these stabilization exercises with general exercises led to positive results. Individually designed and supervised programs are more effective than standard programs, though group programs may be more effective for some individuals as they could improve adherence and increase motivation, and motivation programs with exercise programs improved long-term pain and disability. No single exercise is completely effective-programs should be comprehensive and focus on endurance. |
| Lumbar segmental ‘Instability’: Clinical Presentation and Specific Stabilizing Exercise Management  O’Sullivan PB | 2000 | To outline common clinical presentations of varying instabilities of the lumbar spine and present specific exercises to manage each classification using a motor learning model. | The author lays out clinical classifications for lumbar instability that are based on clinical observations. They are based on mechanism of injury, aggravating activities, and aberrant movement patterns. | Key exam findings by classification:   * Flexion: central LBP, injured or aggravated by flexion, loss of segmental lumbar lordosis, use of UE to assist return to neutral trunk from flexion, loss of segmental ext * Extension: central LBP, injured or aggravated by ext, increase in segmental lordosis, use of UE to assist return to neutral trunk from flexion, hold lordosis until mid-range flexion with an arc of pain * Lateral shift: unilateral LBP, injured or aggravated by reaching or rotating to one direction while flexed, loss of segmental lordosis, tone on ipsilateral erector spinae, shift accentuated when standing on ipsilateral LE * Multi-directional: all weight bearing postures are painful, may assume any of above postures, muscles spasms, difficulty achieving neutral lordosis   All classifications are associated with an inability to activate the deep abdominals independent of the RA | The author lays out a progression for management of lumbar instability following the stages of motor learning.   1. Cognitive stage: train isolated contraction of the TA, then train independence of pelvis and lower lumbar spine from thoracic spine and hips, should co-contract pelvis floor while maintaining normal respiration; progress once patient can hold contraction in sitting, standing, quadruped and lying for 60 seconds 2. Associative stage: identify faulty and provocative movement patterns, break them down into component parts, and practice each part while holding contraction for high repetitions; contractions should be practiced daily during functional activities 3. Autonomous stage: the goal of this progression, patient performs contraction automatically through daily activities |
| Low Back Stability: From Formal Description to Issues for Performance and Rehabilitation  McGill S | 2001 | To synthesize the scientific foundation for concepts of lumbar stability and describe a safe, beginner’s program for increased stability and daily maintenance of low back health. | The author provides input from evidence as well as personal studies and empirical evidence. | We naturally avoid full spinal flexion by 2-3 degrees, but random motor control error can lead to temporary instability at just one vertebral level, resulting in injury. Spinal stability is achieved through modest levels of coactivation of paraspinal and ab wall muscles. The “margin of safety” balance between mobility and stability is compromised when these muscles have insufficient endurance. | This article is reminiscent of the same author’s article from 1998, previously described in this table. To review:   * endurance is more protective than strength * maintain a neutral lordosis while loading * side bridge for quadratus lumborum and obliques * crunches for RA * quadruped LE ext for back extensors   Progression for each exercise are pictured. |
| Systematic Review: Strategies for Using Exercise Therapy to Improve Outcomes in Chronic Low Back Pain  Hayden J, et al. | 2005 | To identify the characteristics of exercise programs for CLBP that are most associated with decreased pain and improved function. | This review included a multivariable random-effects meta-regression of 43 RCTs involving patients with pain duration >12 weeks. Exercise interventions were characterized by program design, delivery type, dose or intensity, inclusion of additional interventions, and type of exercises included. | There were improved pain and functional scores for: individually designed exercise programs, supervised home exercises with therapist follow-up with group and individual supervision deliveries, and high dose or high intensity exercise programs. Stretching led to largest improvement for pain outcomes while strengthening most improved function. | The most effective exercise strategy for CLBP appears to be individually designed exercise programs delivered in a supervised format and encouraging adherence to achieve high dosage over longer periods of time. Adding other conservative treatment, such as advice to stay active, NSAIDS, or manual therapy, also results in improved pain and function outcomes. |
| Impaired Postural Control of the Lumbar Spine is Associated with Delayed Muscle Response Times in Patients with Chronic Idiopathic Low Back Pain  Radebold A, et al. | 2001 | To determine whether patients with low back pain will exhibit poorer postural control in unstable sitting and to examine the relationship between this postural performance and muscle response latencies following sudden loading | 16 patients with CLBP and 14 controls were placed in unstable sitting conditions with decreasingly stability to measure postural sway, then underwent quick release from an isometric contraction to record with EMG muscle response times | Subjects with CLBP show significantly greater sway in unstable sitting, differences between the groups becoming more pronounced as difficulty increased.  Trunk muscle response times were greater for patients with CLBP in all directions  Average trunk muscle onset time was significantly correlated with balance performance with closed eyes, but not with open eyes | * higher reliance on visual input in CLBP due to decreased kinesthetic sense/ proprioception in the trunk muscles and ligaments * healthy subjects performed better in A/P direction, where CLBP subjects had no difference between directions * if postural control is impaired, the dynamic stability of the lumbar spine may be compromised, making a person vulnerable to low back injury or aggravating an existing problem |
| Altered Abdominal Muscle Recruitment in Patients with Chronic Back Pain following a Specific Exercise Intervention  O’Sullivan, et al. | 1998 | To investigate whether a specific exercise intervention directed at the deep abdominal muscles results in increased ability to automatically activate this group in isolation from the RA during dynamic activity | 10 weeks; trained ADIM as described by Richardson and specific contractions of deep abdominals with co-contraction of LM until patients could hold 10 contractions 10 seconds each; progressed to holding during movement of limbs, both in supine and quadruped. Also performed as HEP daily. Progressed to functional activities.  Control: 10 weeks; weekly general exercise such as walking, swimming, gym | As measured with a double leg raise with EMG: the experimental group had a significant increase in IO activation and no change in RA activation. The control group had an increase in RA activation. This increase was seen in control subjects who reported regularly doing sit-ups.  This study shows you can specifically train the deep abdominals in isolation from the RA and the type of exercise administered to muscle groups influences the manner by which the muscle is automatically recruited during trunk loading tasks. | * IO and TA provide rotational and lateral control to spine while maintain levels of intra-abdominal pressure and imparting tension to thoracolumbar fascia; RA and EO are designed for torque production * Research has shown inability to perform the ADIM differentiates CLBP patients from controls * We want to prescribe exercise that enhances the capacity of the neuromuscular system to stabilize the dynamic stability of the spine to reduce symptoms and increase functional mobility, so specific training for deep abdominals in co-contraction with LM seems most appropriate |
| Motor Control Exercises for Chronic Low Back Pain: A Randomized Placebo-Controlled Trial  Costa et al. | 2009 | To conduct the first placebo controlled study investigating the effect of motor control exercises for patients with chronic low back pain. | 12 half hour sessions over 8 weeks  Stage 1) train independent activation of TA, pelvic floor contraction, breathing control, control of spinal posture and movement; were ready to progress when could maintain isolated contraction of TA for 10 seconds 10 times  Stage 2) coordination of the trained contractions in static tasks then functional and dynamic tasks  HEP throughout  Control: 20 minutes of detuned shortwave diathermy, 5 minutes of detuned ultrasound | Motor control exercise improved activity and global impression of recovery. There was a significant effect on VAS pain rating at 12 months. 88% of the motor control group and 98% of the control group had persistent and recurrent pain (never made it >30 days without pain) at 12 months. Exercise improved activity limitation over the control until 12 months where there was no significant difference between the groups.  Motor control exercise produces beneficial but small clinical improvements over a placebo | * there was no evidence that depression was a predictor for response to treatment * most of the effects observed at short-term follow up were maintained at 12 months * this study’s findings suggest complete recovery is unlikely in these individuals * the findings in this study support earlier studies suggesting that patients who have continuing impairment of deep trunk muscle activation have more recurrent episodes of low back pain |
| Motor Control Learning in Chronic Low Back Pain  Magnusson et al. | 2008 | 1. assess effect of computerized motion biofeedback program based on motor learning in CLBP patients 2. compared outcomes of standard rehab + computerized biofeedback vs. standard rehab 3. assess effect of repeated feeback in long-term motor learning | 5 1-hour sessions of a standard back rehab program involving encouragement to remain active, maintain good posture, trunk strengthening, mobility and dynamic control, self-management, and lifestyle modification. The treatment group also had 10 sessions of “guided motion” biofeedback (BF) training with the Targeting section of BackWorks Software with the Back Tracker in tethered mode (patients must learn to move appropriately to make their on-screen icon reach a target). Pts were given auditory, visual and post-performance feedback. | VAS scores immediately, at 6 weeks and 6 months were significantly better in the BF group. SF-36 scores were significantly higher in the BF group for physical functioning at 6 weeks and 6 months; for roles of limitations immediately, at 6 weeks, and at 6 months; and for bodily pain at 6 weeks and 6 months, with both groups having significant decrease in bodily pain immediately following treatment. Both groups had improved lumbar range of motion.  Biofeedback has short and long-term benefits when used to supplement a back rehab program. | * this study aimed to retrain proprioception and motor control/coordination for everyday movements rather than changing muscle recruitment patterns * the authors believe the Back Tracker is more effective than EMG for real-life application of back rehab * biofeedback should be: multimodal so perceptive and cognitive function are involved, attractive and motivating to keep the participant attentive, easy to understand to avoid information overload |
| Motor Control Exercises, Sling Exercises, and General Exercises for Patients with Chronic Low Back Pain: A Randomized Controlled Trial with 1-Year Follow-Up  Unsgaard et al. | 2010 | The purpose of this study is to compare supervised low-load motor control exercises and supervised high-load sling exercises with general exercises in the early phase of rehabilitation for patients with chronic LBP. | Once a week for 8 weeks, encouraged to stay active in daily life  MC group: Motor Control Exercises: 40 minutes/week, used ultrasound imaging to teach and achieve controlled isolated co-contraction of the TA, LM, and pelvic floor muscles supine, sitting, standing, and functional activities  Sling Exercises: 40 minutes/week, subjects performed back exercises with unloading elastic bands attached to their pelvis to help maintain neutral spine position  General Exercise: 1 hour/week, stretching of lumbar and extremity muscles, lumbar AROM against resistance with 10 repetitions in each of 3 sets. | No significant differences between groups immediately post-intervention for pain, activity limitation, fingertip-to-floor, fear-avoidance beliefs for physical activity or work. However, confidence intervals for improved outcomes spanned clinically important differences in favor of motor control exercise. | * more patients withdrew from the sling exercise group than the MC group, and twice as many participants dropped out of the general exercise than the other two * use of medicine as a result of back pain was 24% and in the MC group versus 42% in the general exercise group, this may not have been statistically significant but appears clinically so * 41-48% of patients in all three groups sough another intervention before this study was completed * effect sizes for pain were in favor of motor control |
| Comparison of General Exercise, Motor Control Exercise, and Spinal Manipulative Therapy for Chronic Low Back Pain: A Randomized Trial  Ferriera et al. | 2007 | The study is intended to compare the effects of general exercise, spinal manipulative therapy, and motor control exercises for patients with chronic LBP. | General exercise: 1 hour/week for 8 weeks, based on 'Back to Fitness' program; 8 person class involving warm up, 10 exercises performed for one minute each, warm down, relaxation session, "tip of the day". Participants encouraged to avoid rest, remain active, and take up activities they found enjoyable.  Motor Control exercise :12 1 hour sessions over 8 weeks. ADIM concurrently with pelvic floor muscles, US used for feedback; progressed into functional tasks  Both exercise groups were coached on pacing, setting progressive goals, self-monitoring, and problem solving.  Spinal Manipulative therapy: These patients treated only with joint mobilization or manipulation to the spine or pelvis at a dose and variation decided by the treating therapist. | At 8 weeks, the groups receiving motor control (p=.004 for Patient Specific Functional Scale, <.0001 for Global Percieved Effect) or spinal manipulative therapy (p=.016 for PSFS, p=.004 for GPE) improved more than the group receiving general exercise. At 6 and 12 months, there were small but not statistically significant differences between groups, with general exercise on average having less of an effect. | * authors speculated that had an HEP been incorporated with manipulation therapy they expect it may have shown even better results than found in this study-worth investigating * many patients in this study had been on disability for more than 3 years and from low socio-economic status, so it would be expected the findings of this study could generalize to similar populations and those with less chronicity * consider how intervention was applied: general exercise was in groups… there may have been better results for general exercise if it had been conducted individually as other studies have shown individual instruction to be superior to group instruction for CLBP |
| Altered Trunk Muscle Recruitment in People with Low Back Pain with Upper Limb Movement at Different Speeds  Hodges, RIcharson | 1999 | To investigate activation of the trunk muscles with movements at varying speeds of limb in patients with and without CLBP | There was no intervention in this study, just performance of shoulder flexion at three different speeds to measure feedforward and reactive trunk muscle response. Speed of arm movement was also studied to ensure no differences between the groups as confounding variables. | Onset of TA and IO are delayed in CLBP patients compared to pain-free controls at fast speeds. TA was delayed in CLBP patients at intermediate speeds in the small number of trials during which it was detected at all. There were no differences between the groups at slow speeds.  There were no differences in movements speeds between groups. | * in people with no history of LBP, rapid arm movement is preceded by contraction of erector spinae, TA, IO showing feedforward programming of the CNS * there was a profound absence of contraction in ab muscles in CLBP at intermediate speeds * recruitment patterns at slow speeds were consistent between groups |
| Muscle Activation Changes After Exercise Rehabilitation for Chronic Low Back Pain  Marshall, Murphy | 2008 | To investigate changes in feedforward activation of TA, IO and erector spinae (ES) as well as relaxation of ES during end range trunk flexion following various interventions. | For 4 weeks patients chose to either receive manipulation or modalities, ADIM, ergonomics training, and treatment of any acute problems. Then subjects were randomized into exercise groups for 12 weeks. They received either weekly supervised training with Swiss balls progressed every 4 weeks (first isometric focus, then controlled concentric/eccentric training, then dynamic exercises) or a prescription for an HEP of “common” low back exercises with checkups every 4 weeks (including dips, quadruped, lunges, prone hold on elbows) | Oswestry Disability Index scores improved in all groups at 56 weeks with supervised exercise group improved more than HEP group at 16 weeks and no effect of treatment at 8 weeks. There was no effect of treatment on feedforward activation though latency time was significantly decreased in both groups. There were significant increases in both groups for flexion relaxation in ES in both groups with supervised exercise having significant improvement over the HEP group.  There was no correlation of improvement to treatment with manipulation therapy or not. | * the authors conclude that supervised exercise is better than unsupervised, but to me the findings just suggest that swiss ball training is better than dips, lunges, etc. * change in flexion relaxation response shows neuromuscular changes in response to an exercise program * flexion relaxation response is an adaption that reduces activity of the ES by stretch inhibition allowing passive spinal structures and deep back extensors to provide tension to maintain lumbar stability; this measure has been shown to discriminate between those with and without CLBP * feedforward response changes were side and direction specific6 |
| Motor Control Exercise for Persistent, Nonspecific Low Back Pain: A Systematic Review  Macedo et al. | 2009 | To conduct a systematic review of randomized controlled trials evaluating the effectives of motor control exercise for persistent low back pain | Selected studies were divided into those examining motor control exercises (MCE) versus minimal intervention (MI)or MCE as a supplement to another program (in which MCE comprised at least 40% of the treatment program), MCE versus manual therapy (MT), MCE versus other exercise (E), and MCE versus surgery (lumbar fusion with transpedicular screws of the L4-5 segments or L5-S1) | MCE vs MI: MCE statistically significant over MI in decreasing pain at short-term (<3 months), intermediate (3-12 months), and long-term (>=12 months) and in decresing disability at long term. No evidence for improving quality of life (QoL).  MCE vs MT: Pain and disability outcomes favored MCE but effects were small and only statistically significant in 2/6 studies. Significant favoring of MCE for pain and disability at intermediate. QoL measures favored MCE at short term and MT at long-term, but the effects were small.  MCE vs E: 5/6 favored MCE but all treatment effects were small, only 1 was statistically significant. MCE was better than E only for reduction of disability at short-term.  MCE vs surgery: one study found no significant differences for pain, disability, or QoL at long-term | * this review did not find convincing evidence that MCE is more valuable than less time consuming forms of intervention, though there was fairly consistently at least a small effect favoring MCE * the findings that MCE may be as good at stabilizing the spine as invasive spine surgery is very clinically significant * the authors note that due to the small effect noted in most studies, it may be worth examining a clinical prediction rule to define a subgroup of patients most appropriate for MCE |