



## Publications involving Redcord





1. **Yun K, Lee S, Park J.** Effects of closed chain exercises for the lumbar region performed with local vibration applied to an unstable support surface on the thickness and length of the transverse abdominis *Journal of Physical Therapy Science* 2015;27(1):101-3.
2. **Park J, Lee S, Hwangbo G.** The effects of a bridge exercise with vibration training and an unstable base of support on lumbar stabilization. *Journal of Physical Therapy Science* 2015;27(1):63-5.
3. **Cho SH, Baek IH, Cheon JY, Cho MJ, Choi MY, Jung DH.** Effect of the Push-up Plus (PUP) Exercise at Different Shoulder Rotation Angles on Shoulder Muscle Activities. *Journal of Physical Therapy Science* 2014;26(11):1737-40.
4. **Lee S, Lee D, Park J.** Effect of the Shoulder Flexion Angle in the Sagittal Plane on the Muscle Activities of the Upper Extremities when Performing Push-up plus Exercises on an Unstable Surface. *Journal of Physical Therapy Science* 2014;26(10):1589-91.
5. **Chang WD, Huang WS, Lee CL, Lin HY, Lai PT.** Effects of Open and Closed Kinetic Chains of Sling Exercise Therapy on the Muscle Activity of the Vastus Medialis Oblique and Vastus Lateralis. *Journal of Physical Therapy Science* 2014;26(8):1363-6.
6. **Lee JS, Yang SH, Koog YH, Jun HJ, Kim SH, Kim KJ.** Effectiveness of sling exercise for chronic low back pain: a systematic review. *Journal of Physical Therapy Science* 2014;26(8):1301-6.
7. **Kim ER, Oh JS, Yoo WG.** Effect of Vibration Frequency on Serratus Anterior Muscle Activity during Performance of the Push-up Plus with a Redcord Sling. *Journal of Physical Therapy Science* 2014;26(8):1275-6.
8. **Lee J, Lee H, Lee W.** Effect of Weight-bearing Therapeutic Exercise on the Q-angle and Muscle Activity Onset Times of Elite Athletes with Patellofemoral Pain Syndrome: A Randomized Controlled Trial *Journal of Physical Therapy Science* 2014;26(7):989–92.
9. **Yue YS, Wang XD, Xie B, Li ZH, Chen BL, Wang XQ, Zhu Y.** Sling Exercise for Chronic Low Back Pain: A Systematic Review and Meta-Analysis. *PLoS ONE* 2014;9(6):e99307.
10. **Jeong SY, Chung SH, Shim JH.** Comparison of Upper Trapezius, Anterior Deltoid, and Serratus Anterior Muscle Activity during Pushup plus Exercise on Slings and a Stable Surface. *Journal of Physical Therapy Science* 2014;26(6):937–9.
11. **Lee JS, Lee HG.** Effects of Sling Exercise Therapy on Trunk Muscle Activation and Balance in Chronic Hemiplegic Patients. *Journal of Physical Therapy Science* 2014;26(5):655–9.
12. **Maeo S, Chou T, Yamamoto M, Kanehisa H.** Muscular activities during sling- and ground-based push-up exercise. *BMC Research Notes* 2014;7:192
13. **Park HJ, Oh DW, Kim SY.** Effects of integrating hip movements into bridge exercises on electromyographic activities of selected trunk muscles in healthy individuals. *Manual Therapy* 2014;19(3):246-51
14. **Park JH, Hwangbo G.** The Effect of Trunk Stabilization Exercises Using a Sling on the Balance of Patients with Hemiplegia. *Journal of Physical Therapy Science* 2014;26(2):219–21
15. **Kim GY, Kin SH.** Effects of Push-ups Plus Sling Exercise on Muscle Activation and Cross-sectional Area of the Multifidus Muscle in Patients with Low Back Pain. *Journal of Physical Therapy Science* 2013;25(12):1575–8
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**Yun K, Lee S, Park J.**

Effects of closed chain exercises for the lumbar region performed with local vibration applied to an unstable support surface on the thickness and length of the transverse abdominis

*Journal of Physical Therapy Science* 2015;27(1):101-3.

**Purpose:** This study examined the effects of closed chain exercises performed with local vibration applied to an unstable support surface on the thickness and length of the transverse abdominis.

**Subjects:** The subjects were 64 healthy university students who were randomly assigned to a bridge exercise with sling and vibration group (BESVG, n=30) and a bridge exercise with sling group (BESG, n=34).

**Methods:** The bridge exercise was repeated four times per set and a total of 18 sets were performed: 9 sets in a supine position and 9 sets in a prone position. In both the BESVG and the BESG groups, the thickness and length of the transverse abdominis (TrA) were measured using ultrasonography with the abdomen "drawn-in" and the pressure of a biofeedback unit maintained at 40 mmHg, both before and after the intervention.

**Results:** In intra-group comparisons, the BESVG showed significant increases in the thickness of the TrA and significant decreases in the length of the TrA. The BESG showed significant increases in the thickness of the TrA. The BESVG showed significant increases in the thickness of the TrA and significant decreases in the length of the TrA compared to BESG.

**Conclusion:** Closed chain exercises for the lumbar region performed with local vibration applied to slings, which are unstable support surfaces, are an effective intervention for altering the thickness and length of the TrA.

**Key words:** Closed chain exercise, Vibration, Transverse abdominis



**Park J, Lee S, Hwangbo G.**

The effects of a bridge exercise with vibration training and an unstable base of support on lumbar stabilization.

*Journal of Physical Therapy Science* 2015;27(1):63-5.

**Purpose:** The aim of this study was to examine the effects of a bridge exercise with vibration training and an unstable base of support on lumbar stabilization.

**Subjects:** This study assigned healthy adults in their 20s to a bridge exercise with a sling and vibration group (BESV, n=20) and a bridge exercise with a sling group (BESG, n=20).

**Methods:** Electromyography was used to comparatively analyze the activity of the internal obliques (IO), external obliques (EO), and rectus abdominis (RA) when local vibration was applied during a bridge exercise that used a sling as an unstable base of support.

**Results:** There were statistically significant increases in the activity of the IO and EO within each group after the intervention. The activity of the IO and the EO was significantly higher in the BESV group than in the BES group after the intervention.

**Conclusion:** The bridge exercise performed using vibration training on an unstable base of support increased the activity of the IO and the EO, which improved lumbar stabilization.

**Key words:** Bridge exercise, Vibration, Lumbar stabilization



**Cho SH, Baek IH, Cheon JY, Cho MJ, Choi MY, Jung DH.**

Effect of the Push-up Plus (PUP) Exercise at Different Shoulder Rotation Angles on Shoulder Muscle Activities.

*Journal of Physical Therapy Science* 2014;26(11):1737-40.

**Purpose:** Although the Push-Up Plus is a useful exercise method for shoulder stabilization, few studies have examined its effects at different angles of shoulder rotation. Therefore, the present study investigated the most effective exercise method for shoulder stabilization by analyzing muscle activities of the rotator cuff muscles at different angles of shoulder rotation.

**Subjects:** Fifteen healthy university students in their 20s were the subjects of this study.

**Methods:** Changes in muscle EMG related to shoulder stabilization were analyzed by performing the Push-Up Plus in shoulder positions of neutral, internal and external rotation.

**Results:** The highest muscle activity was found in external rotation, and in internal rotation the pectoralis major and levator scapula showed significantly lower activities than the other positions.

**Conclusion:** Selectively changing the rotation angle of the shoulder for different purposes of the shoulder exercise would be an effective exercise method.

**Key words:** Shoulder, Stabilization, Rotation





**Lee S, Lee D, Park J.**

Effect of the Shoulder Flexion Angle in the Sagittal Plane on the Muscle Activities of the Upper Extremities when Performing Push-up plus Exercises on an Unstable Surface.

*Journal of Physical Therapy Science 2014;26(10):1589-91.*

**Purpose:** The purpose of this study was to investigate the effect of the shoulder flexion angle on the muscle activities of the upper extremities when performing the push-up plus exercise (PUPE) on an unstable surface with the forearm in the external rotation position.

**Subjects:** The subjects were conducted on 15 normal male adults.

**Methods:** A sling device was used for the unstable surface, and PUPE was performed with the forearm in the external rotation position. The shoulder flexion angles measured in the sagittal plane were 110°, 90°, and 70°. Electromyography was used for a comparative analysis of the muscle activities of the serratus anterior (SA), the pectoralis major (PM), and the upper trapezius (UT).

**Results:** In the intra-group comparison, the muscle activity of SA was statistically the highest when the shoulder-flexion angle was 110°.

**Conclusion:** Performing PUPE on an unstable surface, the muscle activity of the SA is activated the most when the shoulder flexion angle is 110° and the forearm is in the external rotation position.

**Key words:** Push-up plus exercise, Serratus anterior, Electromyography



**Chang WD, Huang WS, Lee CL, Lin HY, Lai PT.**

Effects of Open and Closed Kinetic Chains of Sling Exercise Therapy on the Muscle Activity of the Vastus Medialis Oblique and Vastus Lateralis.

*Journal of Physical Therapy Science* 2014;26(8):1363-6.

**Purpose:** The muscle strength of the quadriceps muscle is critical in patellofemoral pain syndrome. The quadriceps muscle supplies the power for dynamic patellar movement, and the vastus medialis oblique (VMO) and vastus lateralis (VL) enable the patella to stabilize during tracking. We followed the theories about open and closed kinetic chain exercises to design two exercises, sling open chain knee extension (SOCKE) exercise and sling closed chain knee extension (SCCKE) exercise. The purpose of our study was to research the changes in quadriceps muscle activity during both exercises.

**Methods:** Electromyographic analysis was used to explore the different effects of the two exercises. The MVC% was calculated for the VMO and VL during exercise for analysis.

**Results:** We found that the mean MVC% values of the VMO and VL during the SOCKE exercise were higher than those during the SCCKE exercise. The ratio of the VMO to VL was  $1.0 \pm 0.19$  during the SOCKE exercise and  $1.11 \pm 0.15$  during the SCCKE exercise.

**Conclusions:** The SOCKE exercise is targeted at quadriceps muscle training and has a recruitment effect on the VMO. The beneficial effect of the SOCKE exercise is better than that of the SCCKE exercise.

**Key words:** Patellofemoral pain syndrome, Sling exercise therapy, Electromyography



**Lee JS, Yang SH, Koog YH, Jun HJ, Kim SH, Kim KJ.**

Effectiveness of sling exercise for chronic low back pain: a systematic review.

*Journal of Physical Therapy Science* 2014;26(8):1301-6.

**Purpose:** This study investigated effects of sling exercise for patients with chronic low back pain.

**Methods:** We reviewed all relevant papers indexed in PubMed, SCOPUS, and the Cochrane Registered Trials. Eligible trials were randomized controlled trials that compared sling exercise with any type of treatment. We extracted data on muscle thickness, muscle activation, pain, and disability, and assessed the methodological quality of the data. Seven studies met our inclusion criteria.

**Results:** When sling exercise had an impact on activation of the trunk muscles, increasing the trunk muscle thickness, and the reduction in pain and disability had been assessed shortly after the final exercise session, it was more effective than general exercise at activating trunk muscles, but not more effective at increasing trunk muscle thickness and improving pain and disability than general exercise.

**Conclusion:** As sling therapy studies are based on a small number of trials, we cannot draw conclusions about the therapeutic effects of sling exercise. When segmental stabilizing exercise and individually designed programs are added to sling exercise, it increases the effectiveness of sling exercise at improving low back pain. This should be the focus of future studies.

**Key words:** Chronic low back pain; Sling exercise; Systematic review



**Kim ER, Oh JS, Yoo WG.**

Effect of Vibration Frequency on Serratus Anterior Muscle Activity during Performance of the Push-up Plus with a Redcord Sling.

*Journal of Physical Therapy Science* 2014;26(8):1275-6.

**Purpose:** We investigated the effect of vibration at various frequencies on serratus anterior (SA) muscle activity.

**Subjects:** Ten male subjects were recruited.

**Methods:** The subjects performed the push-up plus exercise supported by straps above the surface and vertical ropes in the Redcord sling. During the push-up plus, vibrations of 0, 30, 50, or 90 Hz were applied to the Redcord sling using a mechanical vibration apparatus attached to the rope. SA muscle activity was recorded using electromyography.

**Results:** SA muscle activity at the 50 Hz vibration frequency was significantly higher than that of no vibration.

**Conclusion:** Performing the push-up plus using a Redcord sling with mechanical vibration of 50 Hz effectively increased SA muscle activity

**Key words:** Mechanical vibration; Push-up plus; Serratus anterior



**Lee J, Lee H, Lee W.**

Effect of Weight-bearing Therapeutic Exercise on the Q-angle and Muscle Activity Onset Times of Elite Athletes with Patellofemoral Pain Syndrome: A Randomized Controlled Trial

*Journal of Physical Therapy Science* 2014;26(7):989–92.

**Purpose:** The purpose of this study was to determine the effect of a weight-bearing therapeutic exercise program for elite athletes diagnosed as having patellofemoral pain syndrome (PFPS).

**Subjects:** The subjects were 34 elite athletes from the Seoul T Center. They were randomly allocated to three groups: an elastic band exercise group (EBG), a sling exercise group (SEG), or a control group (CG).

**Methods:** Therapeutic exercises were performed 3 times a week for 8 weeks. The visual analogue scale (VAS) hamstring length, and static and dynamic Q angles were used to test the exercise effect of the exercises, as well as the onset time of electromyographic activity of vastus medialis oblique (VMO) and vastus lateralis (VL).

**Results:** Decrease of the dynamic Q-angle in EBG was significant and significantly greater than that in CG. The decrease in VAS in SEG was significant and significantly greater than that in CG. There were significant differences in the VL and VMO activity onset times in SEG between pre- and post-test, and their differences between pre- and post-test were also significantly different.

**Conclusion:** Weight-bearing therapeutic exercise is hoped that clinicians will use this information for better implementation of effective exercise methods for elite athletes with PFPS.

**Key words:** Electromyographic onset time, Patellofemoral pain syndrome, Q-angle



**Yue YS, Wang XD, Xie B, Li ZH, Chen BL, Wang XQ, Zhu Y.**

Sling Exercise for Chronic Low Back Pain: A Systematic Review and Meta-Analysis.

*PLoS ONE* 2014;9(6):e99307.

**Background:** Trials on sling exercise (SE), commonly performed to manage chronic low back pain (LBP), yield conflicting results. This study aimed to review the effects of SE on chronic LBP.

**Methods:** The randomized controlled trials comparing SE with other treatments or no treatment, published up to August 2013, were identified by electronic searches. Primary outcomes were pain, function, and return to work. The weighted mean difference (WMD) and 95% confidence interval (CI) were calculated, using a random-effects model.

**Results:** Risk of bias was rated as high in 9 included trials, where some important quality components such as blinding were absent and sample sizes were generally small. We found no clinically relevant differences in pain or function between SE and other forms of exercise, traditional Chinese medical therapy, or in addition to acupuncture. Based on two trials, SE was more effective than thermomagnetic therapy at reducing pain (short-term: WMD  $-13.90$ , 95% CI  $-22.19$  to  $-5.62$ ; long-term: WMD  $-26.20$ , 95% CI  $-31.32$  to  $-21.08$ ) and improving function (short-term: WMD  $-10.54$ , 95% CI  $-14.32$  to  $-6.75$ ; long-term: WMD  $-25.75$ , 95% CI  $-30.79$  to  $-20.71$ ). In one trial we found statistically significant differences between SE and physical agents combined with drug therapy (meloxicam combined with eperisone hydrochloride) but of borderline clinical relevance for pain (short-term: WMD  $-15.00$ , 95% CI  $-19.64$  to  $210.36$ ) and function (short-term: WMD  $210.00$ ; 95% CI  $2$   $13.70$  to  $26.30$ ). There was substantial heterogeneity among the two trials comparing SE and thermomagnetic therapy; both these trials and the trial comparing SE with physical agents combined with drug therapy had serious methodological limitations.

**Interpretation:** Based on limited evidence from 2 trials, SE was more effective for LBP than thermomagnetic therapy. Clinically relevant differences in effects between SE and other forms of exercise, physical agents combined with drug therapy, traditional Chinese medical therapy, or in addition to acupuncture could not be found. More high-quality randomized trials on the topic are warranted.



**Jeong SY, Chung SH, Shim JH.**

Comparison of Upper Trapezius, Anterior Deltoid, and Serratus Anterior Muscle Activity during Pushup plus Exercise on Slings and a Stable Surface.

*Journal of Physical Therapy Science* 2014;26(6):937–9.

**Purpose:** The purpose of this study was to identify effects of push-up plus exercise on different support surfaces on upper extremity muscular activity.

**Subjects:** The subjects were 28 students (10 males, 18 females) at B University. [Methods] The subjects performed push-up plus exercises either on slings or on a fixed support.

**Results:** Push-up plus exercises on slings showed significant increases in the muscle activity of the trapezius (upper fiber), deltoid (anterior fiber), and serratus anterior muscles compared with stabilization exercises on a fixed support.

**Conclusion:** Based on these results, it is considered that performance of the push-up plus exercise on slings will increase scapular muscle activity.

**Key words:** Push-up plus exercise, Sling, Muscle activity



**Lee JS, Lee HG.**

Effects of Sling Exercise Therapy on Trunk Muscle Activation and Balance in Chronic Hemiplegic Patients.

*Journal of Physical Therapy Science* 2014;26(5):655–9.

**Purpose:** Weakening of trunk muscles in stroke patients hinders functional ability, safety and balance. To confirm whether strengthening trunk muscles could facilitate rehabilitation of stroke patients, we investigated the effectiveness of sling exercise therapy (SET) using closed kinetic chain exercises to activate trunk muscles and improve balance in stroke patients.

**Subjects and Methods:** Twenty stroke patients with chronic hemiplegia were equally divided into 2 groups, a SET group and a control group that performed regular exercises on a mat with the assistance of a table. Patients in both groups exercised for 30 min, three times per week for 4 weeks. Trunk muscle activity was measured using surface electromyography, whereas balance was measured using the Berg Balance Scale, Frailty and Injuries Cooperative Studies of Intervention Technique, Timed Up & Go test, and BioRescue before and after the 4-week experimental period.

**Results:** Trunk muscle activity and balance before and after intervention in both groups were significantly different. However, no significant differences were observed between the 2 groups.

**Conclusion:** Although SET was not more effective than regular exercise, significant improvement was observed before and after SET. Therefore, SET can be considered effective in strengthening trunk muscles in stroke patients with chronic hemiplegia.

**Key words:** Chronic stroke patients, Sling exercise therapy, Trunk muscles



**Maeo S, Chou T, Yamamoto M, Kanehisa H.**

Muscular activities during sling- and ground-based push-up exercise.

*BMC Research Notes* 2014;7:192

**Background:** This study aimed to clarify the characteristics of muscle activities during push-up exercises performed under sling condition by comparison with those performed under ground condition. We hypothesized that sling-based push-ups induce higher muscle activities than the ground-based push-ups, and its effects are more prominent in dynamic compared to static exercise owing to increased demands of stabilization.

**Findings:** Twenty young males performed sling- and ground-based push-ups in each of static (maintaining the posture with the elbow joint angle at 90 deg) and dynamic (repeating push-ups at a rate of 45 per minute) exercises. Surface electromyograms (EMGs) of the pectoralis major, latissimus dorsi, triceps brachii, biceps brachii, rectus abdominis, external oblique, internal oblique, and erector spinae muscles were recorded during the exercises. The EMG data were normalized to those obtained during maximal voluntary contraction of each muscle (% EMGmax). In the static exercise, sling condition showed significantly higher % EMGmax values than the ground condition in the triceps brachii (+27%: relative to ground condition) and biceps brachii (+128%) as well as the three abdominal muscles (+15% to +27%). In the dynamic exercise, such condition-related differences were more prominent and those in the pectoralis major (+29%) in addition to the aforementioned five muscles (+19% to +144%) were significant.

**Conclusion:** These results supported the hypothesis and indicate that sling-based push-up exercise can provide greater activation in upper limb and anterior trunk muscles than the ground-based push-up exercise.

**Keywords:** Instability, Co-contraction, Electromyography



**Park JH, Hwangbo G.**

The Effect of Trunk Stabilization Exercises Using a Sling on the Balance of Patients with Hemiplegia.

*Journal of Physical Therapy Science* 2014;26(2):219–21

**Purpose:** The purpose of this study was to examine the effects of trunk stabilization exercise using a sling on the balance ability of patients with hemiplegia.

**Subjects:** Forty patients with hemiplegia resulting from stroke were divided into a sling exercise group (SEG, n=20) and a mat exercise group (MEG, n=20).

**Methods:** The SEG conducted the trunk stabilization exercise using a sling, and the MEG performed the trunk stabilization exercise on a mat.

**Results:** The balance ability of both groups significantly improved. Although there were no significant differences between the groups, the SEG showed a greater reduction in the sway area (SA) and the sway length (SL) of the center of the pressure compared to the MEG.

**Conclusion:** We recommend trunk stabilization exercise using a sling as a clinical intervention to improve the balance ability of patients with hemiplegia.

**Key words:** Hemiplegia, Trunk stabilization exercise, Sling



**Kim GY, Kin SH.**

Effects of Push-ups Plus Sling Exercise on Muscle Activation and Cross-sectional Area of the Multifidus Muscle in Patients with Low Back Pain.

*Journal of Physical Therapy Science 2013;25(12):1575–8*

**Purpose:** The purpose of this study was to examine the effect of lumbar stability exercises on chronic low back pain by using sling exercise and push-ups.

**Subjects:** Thirty adult subjects with chronic back pain participated, with 10 adults being assigned to each of 3 exercise groups: general physical therapy (PT), lumbar stability using sling exercises (Sling Ex), and sling exercise plus push-ups (Sling Ex+PU). Each group trained for 30 minutes 3 times a week for 6 weeks. The Oswestry Disability Index (ODI), surface electromyographic (sEMG) activity of the lumbar muscles, and cross-sectional area of the multifidus muscle on computed tomography (CT) were evaluated before and at 2, 4, and 6 weeks of therapy.

**Results:** A significant decrease in ODI was seen in all therapy groups, and this change was greater in the Sling Ex and Sling Ex+PU groups than in the PT group. No changes in sEMG activity were noted in the PT group, whereas significant increases in the sEMG activities of all lumbar muscles were found in the other 2 groups. The increases in the sEMG activities of the rectus abdominis and internal and external oblique muscles of the abdomen were greater in the Sling Ex+PU group than in the other 2 groups.

**Conclusion:** These findings demonstrate that Sling Ex+PU, similar to normal lumbar stabilization exercise, is effective in activating and improving the function of the lumbar muscles. These results suggest that Sling Ex+PU has a positive impact on stabilization of the lumbar region.

**Key words:** Chronic low back pain, Push-up plus, Multifidus muscle

**Lee SK.**

The Effects of Vibration Stimuli Applied to the Shoulder Joint on the Activity of the Muscles Around the Shoulder Joint.

*Journal of Physical Therapy Science 2013;25(11):1407–09*

**Purpose:** The present study compared the muscle activity of the upper trapezius with those of the serratus anterior and the lower trapezius when slings, unstable surfaces, were laterally vibrated, to examine the effects of vibration during sling exercises on shoulder stabilization muscles.

**Methods:** The subjects performed push-up exercises on a sling and maintained isometric contraction in the final stage, while vibration was manually administered to the rope of the sling during the isometric-contraction stage. Vibration within a range of 10 cm was delivered for five seconds at a frequency of 1 Hz in time with a metronome. Vibrations were applied for five seconds at 3 Hz and 3.5 Hz, respectively.

**Results:** The serratus anterior showed a significant differences between isometric contraction with vibration of 3 Hz and isometric contraction with vibration of 3.5 Hz.

**Conclusion:** The upper trapezius and the lower trapezius showed prominent changes in muscle activity at 3.5 Hz, and the serratus anterior showed prominent changes in muscle activity at 3 Hz and 3.5 Hz. Therefore, as vibration frequency increased, making the load-bearing surface more unstable, the recruitment of the upper trapezius, the lower trapezius, and the serratus anterior increased. To perform exercises that selectively strengthen the serratus anterior, the exercises should be performed at a vibration frequency of 3 Hz.

**Key words:** Vibration, Shoulder joint, Muscle activity

**Park HJ, Oh DW, Kim SY.**

Effects of integrating hip movements into bridge exercises on electromyographic activities of selected trunk muscles in healthy individuals

*Manual Therapy* 2013; November 10: Epub ahead of print

This study aimed to identify the electromyographic (EMG) effects in selected trunk muscles after incorporating hip movement into bridging exercise.

Twenty-six healthy adults (13 men and 13 women) volunteered for this experiment. EMG data (% maximum voluntary isometric contraction) were recorded from the rectus abdominis (RA), obliquus internus (OI), erector spinae (ES), and multifidus (MF) muscles of the dominant side while the subjects performed 3 types of bridging exercise, including bridging alone (Bridging 1), bridging with unilateral hip movements (Bridging 2), and bridging with bilateral hip movements (Bridging 3) in a sling suspension system.

The RA and OI showed greater EMG activity during Bridging 2 and 3 compared to Bridging 1, with the greatest OI activity during Bridging 3 ( $p < 0.05$ ), and the activity of the MF appeared to be greater during Bridging 3 than during Bridging 1 and 2 ( $p < 0.05$ ). Furthermore, the OI/RA and MF/ES ratios were significantly higher for Bridging 2 (OI/RA  $\frac{1}{4}$  1.89 1.41; MF/ES  $\frac{1}{4}$  1.03 0.19) and Bridging 3 (OI/RA  $\frac{1}{4}$  2.34 1.86; MF/ES  $\frac{1}{4}$  1.03 0.15) than Bridging 1 (OI/RA  $\frac{1}{4}$  1.35 0.92; MF/ES  $\frac{1}{4}$  0.98 0.16). The OI/RA ratio was significantly higher for Bridging 3 than for Bridging 2.

Based on these results, adding hip abduction and adduction, particularly bilateral movements, could be a useful method to enhance OI and MF EMG activity and their activities relative to global muscles during bridging exercise.

**Keywords:** Bridging exercise, Electromyography, Hip movement, Trunk muscles



**Eom MY, Chung SH, Ko TS.**

Effects of Bridging Exercise on Different Support Surfaces on the Transverse Abdominis.

*Journal of Physical Therapy Science* 2013;25(10):1343–6

**Purpose:** The purpose of this study was to identify the effects of bridging exercise on different support surfaces on the thickness of the musculus transversus abdominis and lower extremity muscle activities.

**Subjects:** Thirty-five students of H University. [Methods] The experimental group (n=18) performed bridging exercise on the sling support surface, and the control group (n=17) performed bridging exercise on a general support surface.

**Results:** Thickness changes in the musculus transversus abdominis were 0.35 cm in the experimental group, and 0.17 cm in the control group, suggesting that the experimental group showed a more significant change. For the lower extremity muscular activity, there was a significant difference between the experimental group and the control group only in the biceps femoris muscle.

**Conclusion:** Based on these results, we consider that bridging exercise on a sling support surface would increase the thickness of the transversus abdominis and lower extremity muscle activities in rehabilitation programs for patients with back pain.

**Key words:** Bridging exercise, Sling exercise, Transversus abdominis



**Choi Y, Kang H.**

The Effects of Sling Exercise Using Vibration on Trunk Muscle Activities of Healthy Adults.

*Journal of Physical Therapy Science* 2013;25(10):1291–4

**Purpose:** This study compared the effects of sling exercises with and without vibration on the muscular activity of the internal oblique (IO), rectus abdominis (RA), multifidus (MF), and erector spinae (ES) muscles of healthy adults.

**Methods:** Eleven healthy university students (11 men) with a mean age of 22.8 years were enrolled in this study. Subjects performed supine and prone bridge exercises with the knees flexed using a sling suspension system with and without vibration. The amplitudes of the EMG activities of selected trunk muscles (internal oblique, rectus abdominis, erector spinae, multifidus) were recorded. Two types of exercise conditions were executed in a random sequence for 5 seconds each. The signals detected from the middle 3 seconds (after discarding the signals of the first and the last one seconds) were used in the analysis. A 3-minute break was given after each exercise to minimize muscle fatigue.

**Results:** During the supine bridge exercise with vibration, the activities of the IO, RA, MF, and ES muscles were significantly higher than those of the supine bridge exercise without vibration. Additionally, during the prone bridge exercise with vibration, the activities of the IO, RA, MF, and ES were significantly higher than those of the prone bridge exercise without vibration.

**Conclusion:** Sling exercises with vibration improved the trunk muscle activities of healthy adults compared to the sling exercises without vibration. The information presented here is important for clinicians who use lumbar stabilization exercises as an evaluation tool or a rehabilitation exercise.

**Key words:** Sling exercise, Vibration, Trunk muscle



**Kim JH, Kim YE, Bae SH, Kim KY.**

The Effect of the Neurac Sling Exercise on Postural Balance Adjustment and Muscular Response Patterns in Chronic Low Back Pain Patients.

Journal of Physical Therapy Science 2013;25(8):1015–9

**Purpose:** This study aimed to examine the effects of the Neurac sling exercise on postural balance adjustment and muscular response patterns in chronic low back pain (CLBP) patients.

**Subjects and Methods:** Sixteen CLBP patients participated in this study. They were randomly and equally assigned to group I, whose members received ordinary physical therapy (40 minutes per time, four times per week), and group II, whose members performed a lumbar stabilization exercise using the Neurac sling after ordinary physical therapy (40 minutes per time, four times per week). The visual analogue scale (VAS) and Oswestry Disability Index (ODI) were used to evaluate exercise effects. BioRescue and electromyography were utilized for the measurement of changes in postural balance adjustment and muscular response patterns, respectively.

**Results:** Both groups saw their VAS and ODI decrease significantly. There were significant decreases in both groups in posturography as well, but group II recorded a greater decrease. There were significant increases in the flexion–relaxation ratio in both groups, and there were significant increases in the extension–flexion ratio in the left L1–2 of group I and in all elements of group II.

**Conclusion:** Lumbar stabilization exercise using the Neurac sling is effective in decreasing pain, improving damaged postural balance adjustment, and normalizing muscle response patterns of CLBP patients.

**Key words:** Chronic low back pain (CLBP), Neurac sling exercise, Postural balance adjustment





**De Mey K, Danneels L, Cagnie B, Borms D, T'Jonck Z, Van Damme E, Cools AM.**

Shoulder muscle activation levels during four closed kinetic chain exercises with and without Redcord slings.

*Journal of Strength and Conditioning Research* 2013;October 29:Epub ahead of print

During resistance training protocols, people are often encouraged to target the scapular stabilizing musculature (middle and lower trapezius and serratus anterior) while minimizing shoulder prime mover activation (upper trapezius and large glenohumeral muscles) in their training regime, especially in overhead athletes with scapular dyskinesis. In order to increase the activation levels in the stabilizing muscles without drastically increasing the activation in the prime movers, unstable surfaces are frequently used during closed kinetic chain exercises (CKC). However, the specific influence of Redcord slings (RS) as an unstable surface tool on the shoulder muscle activation levels have rarely been investigated, despite these results may be used for adequate exercise selection. Therefore, a controlled laboratory study was performed on 47 healthy subjects ( $22 \pm 4.31$  yr;  $176 \pm 0.083$  cm;  $69 \pm 8.57$  kg) during four CKC exercises without and with RS: half push-up, knee push-up, knee prone bridging plus, and pull-up. When using RS, serratus anterior muscle activation decreased during the knee push-up and knee prone bridging plus exercise. In addition, a drastic increase in pectoralis major muscle activation was found during the half push-up and knee prone bridging plus exercise. Consequently, the use of RS does not necessarily imply that higher levels of scapular stabilizer muscle activation will be attained. These findings suggest RS might be an appropriate training tool when used within a general strengthening program, but should not be preferred over a stable base of support when training for specific scapular stabilization purposes.

**Keywords:** shoulder; sling exercises; sEMG



**Kline JB, Krauss JR, Maher SF, Qu X.**

Core Strength Training Using a Combination of Home Exercises and a Dynamic Sling System for the Management of Low Back Pain in Pre-professional Ballet Dancers.

*Journal of Dance Medicine and Science* 2013;17(1):24-33

Estimates of low back pain prevalence in USA ballet dancers range from 8% to 23%. Lumbar stabilization and extensor muscle training has been shown to act as a hypoalgesic for low back pain. Timing and coordination of multifidi and transverse abdominis muscles are recognized as important factors for spinal stabilization. The purpose of this study was to explore the effects of training methods using home exercises and a dynamic sling system on core strength, disability, and low back pain in pre-professional ballet dancers. Five participants were randomly assigned to start a traditional unsupervised lumbar stabilization home exercise program (HEP) or supervised dynamic sling training to strengthen the core and lower extremities. Measurements were taken at baseline and at weeks 3 and 6 for disability using the Patient Specific Functional Scale (PSFS), pain using the Numerical Pain Rating System (NPRS), core strength and endurance using timed plank, side-plank, and bridge positions, and sciatic nerve irritability using the straight leg raise (SLR). Data were analyzed using descriptive statistics. From initial to final measurements, all participants demonstrated an improvement in strength and SLR range, and those with initial pain and disability reported relief of symptoms. These results suggest that dynamic sling training and a HEP may help to increase strength, decrease pain, and improve function in dancers without aggravating sciatic nerve irritation.



**Lee SY, Lee DH, Park JS.**

The Effects of Changes in Hand Position on the Electromyographic Activities of the Shoulder Stabilizer Muscles during Push-up Plus Exercises on Unstable Surfaces.

*Journal of Physical Therapy Science* 2013;25(1):125–8

**Purpose:** The purpose of the present study was to examine the effects of changes in hand position on the electromyographic activities of the shoulder stabilizer muscles during push-up plus exercises (PUPE) on unstable surfaces.

**Subjects:** The subjects of the present study were normal adults in their 20s (n=15). PUPEs were performed with the hands in the neutral positions (NP), internal rotation positions (IRP), and external rotation positions (ERP) using a sling device for the unstable surface.

**Methods:** We measured the electromyographic activities of the wrist flexor (WF), the wrist extensor (WE), the biceps brachii (BB), the triceps brachii (TB), the upper trapezius (UT), the lower trapezius (LT), the serratus anterior (SA), and the pectoralis major (PM). The muscle activities were compared and analyzed using electromyography.

**Results:** When hand position changed, WF activity in NP, and SA activity in ERP were significantly different from their respective activities in the other positions.

**Conclusion:** To selectively enhance the electromyographic activity of the SA during PUPE using a sling device as an unstable surface, we consider performance of PUPE in ERP is an effective intervention.

**Key words:** Push-up plus, Hand position, Sling device



**Kim MK, Jung JM, Chang JS, Lee SK.**

Radiographic Imaging Analysis after Sling Exercises for Hemiplegic Shoulder Subluxation.

*Journal of Physical Therapy Science* 2012;24(11):1099–101

**Purpose:** The aim of this study was evaluate the effect of a sling exercise on shoulder subluxation in stroke patients.

**Subjects:** The subjects of this study were thirty-four stroke patients with subluxation. They were randomly selected and divided into two groups.

**Methods:** The subject group (n=17) performed the sling exercise with traditional therapeutic exercise. The control group (n=17) performed only traditional therapeutic exercise.

**Results:** The results indicate that improvement of corrected vertical distance (cVD), and the ratio of the oblique distance of the affected and unaffected sides (rOD) was greater in the experimental group than in the control group.

**Conclusion:** We suggest that the sling exercise is effective at reducing the severity of hemiplegic shoulder subluxation in post-stroke patients.

**Key words:** Radiographic imaging, Sling exercise, Shoulder subluxation



**Yoo YD, Lee YS.**

The Effect of Core Stabilization Exercises Using a Sling on Pain and Muscle Strength of Patients with Chronic Low Back Pain.

*Journal of Physical Therapy Science* 2012;24(8):671-4

**Abstract.** [Purpose] This study examined the feasibility of using an intervention of core stabilization exercises using a sling to control pain and muscle strength of patients with chronic low back pain. [Subjects] The subjects, 30 chronic low back patients, were divided randomly into two exercise groups: one group performed core stabilization exercises using a sling (n=15), and the other group performed mat exercises group (n=15). Each exercise program was performed three days per week for four weeks. Pain and muscle strength were measured before and after the intervention. Pain was assessed using a visual analogue scale (VAS) and muscle strength was measured with a Tergumed device. [Results] The differences in the VAS scores for the sling exercise and mat exercise program were statistically significant between pre and post intervention in both groups. Muscle strength increases were also statistically significant. However, the comparison of sling exercise and mat exercise program showed no statistically significant differences between the groups, post-intervention. [Conclusion] Both the sling exercise and the mat exercise program reduced chronic low back pain improved patients' lumbar muscle strength, and decreased VAS scores; and the sling exercise was more effective than the mat exercise program. Further study is needed to develop the sling exercise for effective use in clinical practice for the treatment of chronic low back pain.

**Key words:** Chronic low back pain, Core Stabilization Exercise, Sling exercise



**Vasseljen O, Unsgaard-Tøndel M, Westad C, Mork PJ.**

Effect of core stability exercises on feed-forward activation of deep abdominal muscles in chronic low back pain.

*SPINE* 2012;37(13):1101-8

**Study Design.** A randomized controlled trial. **Objective.** To investigate feed-forward activation or timing of abdominal muscle activation in response to rapid shoulder flexion after 8 weeks with core stability exercises, sling exercises, or general exercises in chronic non specific low back pain (LBP) patients. **Summary of Background Data.** Delayed onset in abdominal muscles has been associated with LBP. Low load exercises to volitionally activate the transversus abdominis were introduced to restore trunk muscle activation deficits. More forceful co-contraction exercises have been advocated by others. This study explored whether abdominal muscle onset changed after low-load core stability exercises, high-load sling exercises, or general exercises. **Methods.** Subjects (N = 109) with chronic non specific LBP of at least 3 months' duration were randomly assigned to 8 weekly treatments with low-load core stability exercises, high-load stabilizing exercises in slings, or general exercises in groups. Primary outcome was onset recorded bilaterally by m-mode ultrasound imaging in the deep abdominal muscles in response to rapid shoulder flexion. **Results.** No or small changes were found in onset after treatment. Baseline adjusted between group differences showed a 15 ms (95%confidence interval [CI], 1–28; P = 0.03) and a 19 ms (95% CI,5–33; P < 0.01) improvement with sling relative to core stability and general exercises, respectively, but on 1 side only. There was no association between changes in pain and onset over the intervention period (  $R^2 \leq 0.02$ ). **Conclusion.** Abdominal muscle onset was largely unaffected by 8 weeks of exercises in chronic LBP patients. There was no association between change in onset and LBP. Large individual variations in activation pattern of the deep abdominal muscles may justify exploration of differential effects in subgroups of LBP.

**Key words:** ultrasonography, neurophysiological recruitment, clinical trial, motor control.



**Kang H, Jung J, Yu J.**

Comparison of trunk muscle activity during bridging exercises using a sling in patients with low back pain.

*Journal of Sports Science and Medicine* 2012;11:510-15

The aims of this study were to compare the activation of global and local muscles of the trunk during bridging with sling exercise (BSE), bridging with ball exercise (BBE), and normal bridging exercise (NBE) and to conduct and analyze these exercises in supine and prone positions to prove the effectiveness of sling exercises. Thirty patients with current low back pain (LBP) were recruited. In the supine and prone bridging exercise, each subject lifted their pelvis with their legs and feet in contact with the sling, ball, or normal surface. The electrical activities of the inferior oblique (IO), rectus abdominis (RA), multifidus (MF), and erector spinae (ES) muscles during the bridging exercises on the 3 surfaces were measured using surface electromyography (sEMG). For normalization, maximum sEMG signals were evaluated during each maximum voluntary isometric contraction (MVIC) maneuver. The root mean square during the exercise was normalized as a percentage of the MVIC (%MVIC). In the supine and prone positions, %MVIC of the IO, RA, MF, and ES during BSE was significantly higher than those during BBE and NBE ( $p < 0.05$ ). In the supine position, %MVIC of the RA and ES during BBE was significantly higher than that during NBE ( $p < 0.05$ ). In the prone position, all %MVIC during BBE were significantly higher than NBE ( $p < 0.05$ ). These results verify the theory that the use of an unstable surface increases the activation of global and local trunk muscles during bridging exercises in the supine and prone positions. In conclusion, the use of BSE in a rehabilitation program may have therapeutic effects for patients with LBP by increasing trunk muscle activation.

Key words: Sling, bridging exercise, sEMG, local trunk muscle, global trunk muscle.



**Guthrie RJ, Grindstaff TL, Croy T, Ingersoll CD, Saliba SA.**

The effect of traditional bridging or suspension-exercise bridging on lateral abdominal thickness in individuals with low back pain.

*Journal of Sport Rehabilitation* 2012;21:151-60

Context: Individuals with low back pain (LBP) are thought to benefit from interventions that improve motor control of the lumbopelvic region. It is unknown if therapeutic exercise can acutely facilitate activation of lateral abdominal musculature. Objective: To investigate the ability of 2 types of bridging-exercise progressions to facilitate lateral abdominal muscles during an abdominal drawing-in maneuver (ADIM) in individuals with LBP. Design: Randomized control trial. Setting: University research laboratory. Participants: 51 adults (mean  $\pm$  SD age  $23.1 \pm 6.0$  y, height  $173.6 \pm 10.5$  cm, mass  $74.7 \pm 14.5$  kg, and 64.7% female) with LBP. All participants met 3 of 4 criteria for stabilization-classification LBP or at least 6 best-fit criteria for stabilization classification. Interventions: Participants were randomly assigned to either traditional-bridge progression or suspension-exercise-bridge progression, each with 4 levels of progressive difficulty. They performed 5 repetitions at each level and were progressed based on specific criteria. Main Outcome Measures: Muscle thickness of the external oblique (EO), internal oblique (IO), and transversus abdominis (TrA) was measured during an ADIM using ultrasound imaging preintervention and postintervention. A contraction ratio (contracted thickness:resting thickness) of the EO, IO, and TrA was used to quantify changes in muscle thickness. Results: There was not a significant increase in EO ( $F_{1,47} = 0.44$ ,  $P = .51$ ) or IO ( $F_{1,47} = .30$ ,  $P = .59$ ) contraction ratios after the exercise progression. There was a significant ( $F_{1,47} = 4.05$ ,  $P = .05$ ) group-bytime interaction wherein the traditional-bridge progression (pre =  $1.55 \pm 0.22$ ; post =  $1.65 \pm 0.21$ ) resulted in greater ( $P = .03$ ) TrA contraction ratio after exercise than the suspension-exercise-bridge progression (pre =  $1.61 \pm 0.31$ ; post =  $1.58 \pm 0.28$ ). Conclusion: A single exercise progression did not acutely improve muscle thickness of the EO and IO. The magnitude of change in TrA muscle thickness after the traditional-bridging progression was less than the minimal detectable change, thus not clinically significant.

Keywords: lumbar stabilization, sonography, therapeutic exercise





**Park J, Grindstaff TL, Hart JM, Hertel JN, Ingersoll CD.**

Knee-extension exercise's lack of immediate effect on maximal voluntary quadriceps torque and activation in individuals with anterior knee pain.

*Journal of Sport Rehabilitation* 2012;21:119-26

Context: Weight-bearing (WB) and non-weight-bearing (NWB) exercises are commonly used in rehabilitation programs for patients with anterior knee pain (AKP). Objective: To determine the immediate effects of isolated WB or NWB knee-extension exercises on quadriceps torque output and activation in individuals with AKP. Design: A single-blind randomized controlled trial. Setting: Laboratory. Participants: 30 subjects with self-reported AKP. Interventions: Subjects performed a maximal voluntary isometric contraction (MVIC) of the quadriceps (knee at 90°). Maximal voluntary quadriceps activation was quantified using the central activation ratio (CAR):  $CAR = MVIC / (MVIC + \text{superimposed burst torque})$ . After baseline testing, subjects were randomized to 1 of 3 intervention groups: WB knee extension, NWB knee extension, or control. WB knee-extension exercise was performed as a sling-based exercise, and NWB knee-extension exercise was performed on the Biodex dynamometer. Exercises were performed in 3 sets of 5 repetitions at approximately 55% MVIC. Measurements were obtained at 4 times: baseline and immediately and 15 and 30 min postexercise. Main Outcome Measures: Quadriceps torque output (MVIC: N·m/Kg) and quadriceps activation (CAR). Results: No significant differences in the maximal voluntary quadriceps torque output ( $F_{2,27} = 0.592$ ,  $P = .56$ ) or activation ( $F_{2,27} = 0.069$ ,  $P = .93$ ) were observed among the 3 treatment groups. Conclusions: WB and NWB knee-extension exercises did not acutely change quadriceps torque output or activation. It may be necessary to perform exercises over a number of sessions and incorporate other disinhibitory interventions (eg, cryotherapy) to observe acute changes in quadriceps torque and activation.

Keywords: central activation ratio, strengthening exercise, sling-based exercise unit



**Seo SC, Choi JY, Joo MY, Kim JH, Chang SK.**

Effects of sling exercise and McKenzie exercise program on neck disability, pain, muscle strength and range of motion in chronic neck pain.

*Physical Therapy Rehabilitation Science 2012;1(1);40-8*

**Objective:** The aim of this study was to compare sling exercise group to McKenzie exercise group in patients with chronic neck pain.

**Design:** Two group pretest-posttest design.

**Methods:** Twenty subjects who have chronic neck pain were randomly divided into sling exercise group (n=10) and McKenzie exercise (n=10). Sling exercise group (n=10) received sling exercise for 30 minutes per day, twice a week over a 4 week period. And the other group were exercised McKenzie exercise (n=8) for 30 minutes per day, twice a week over a 4 week period. Neck disability index (NDI), Visual analog scale (VAS), algometer, digital manual muscle tester (MMT) and cervical muscle strength and cervical range of motion (ROM) are closely measured to identify the effect of sling exercise and McKenzie exercise.

**Results:** For NDI, VAS, algometer on both trapezius, both rotation of cervical muscle strength, both lateral flexion of cervical muscle strength, cervical extension of ROM and both lateral flexion of ROM were significantly increased after intervention in sling exercise group ( $p < 0.05$ ), For VAS, algometer on both trapezius, left (Lt.) rotation of cervical muscle strength, Lt. lateral flexion of cervical muscle strength, cervical flexion and extension of ROM and Lt. lateral flexion of ROM were significantly increased after than before intervention in McKenzie exercise group ( $p < 0.05$ ).

**Conclusions:** These study outcomes clearly support the notion that sling and McKenzie exercise improved pain, Muscle strength and ROM of patients with chronic neck pain. These results suggest that sling and McKenzie exercise program is suitable for chronic neck pain.

**Key Words:** Exercise, Muscle strength, Neck pain, Range of Motion



**Huang JS, Pietrosimone BP, Ingersoll CD, Arthur L. Weltman A, Saliba SA.**

Sling Exercise and Traditional Warm-Up Have Similar Effects on the Velocity and Accuracy of Throwing.

*Journal of Strength and Conditioning Research* 2011;25(2):464-71

Throwing is a complex motion that involves the entire body and often puts an inordinate amount of stress on the shoulder and the arm. Warm-up prepares the body for work and can enhance performance. Sling-based exercise (SE) has been theorized to activate muscles, particularly the stabilizers, in a manner beneficial for preactivity warm-up, yet this hypothesis has not been tested. Our purpose was to determine if a warm-up using SE would increase throwing velocity and accuracy compared to a traditional, thrower's 10 warm-up program. Division I baseball players (nonpitchers) (16 men, age: 19.6  $\pm$  1.3, height: 184.2  $\pm$  6.2 cm, mass: 76.9  $\pm$  19.2 kg) volunteered to participate in this crossover study. All subjects underwent both a warm-up routine using a traditional method (Thrower's 10 exercises) and a warm-up routine using closed kinetic chain SE methods (RedCord) on different days separated by 72 hours. Ball velocity and accuracy measures were obtained on 10 throws after either the traditional and SE warm-up regimens. Velocity was recorded using a standard Juggs radar gun (JUGS; Tualatin, OR, USA). Accuracy was recorded using a custom accuracy target. An Analysis of covariance was performed, with the number of throws recorded before the testing was used as a covariate and  $p$ , 0.05 was set a priori. There were no statistical differences between the SE warm-up and Thrower's 10 warm-up for throwing velocity (SE: 74.7  $\pm$  7.5 mph, Thrower's 10: 74.6  $\pm$  7.3 mph  $p$  = 0.874) or accuracy (SE: 115.6  $\pm$  53.7 cm, Thrower's 10: 91.8  $\pm$  55 cm,  $p$  = 0.136). Warming up with SE produced equivalent throwing velocity and accuracy compared to the Thrower's 10 warm-up method. Thus, SE provides an alternative to traditional warm-up.

KEY WORDS collegiate baseball players, Redcord, core, Thrower's 10



**Dannelly BD, Otey SC, Croy T, Harrison B, Rynders C, Hertel J, Weltman A.**

The effectiveness of traditional and sling exercise strength training in novice women.

*Journal of Strength and Conditioning Research* 2011;25(2):464-71

Strength training often combines closed-kinetic-chain exercises (CKCEs) and open kinetic-chain exercises (OKCEs). The CKCE may be more effective for improving performance in lower-body training. Recently, we reported upper-body CKCE (using a commercially available system of ropes and slings, Redcord AS, Staubo, Norway) was as effective as OKCE training for strength gains and that CKCE was more effective than OKCE for improving throwing performance. To our knowledge the effectiveness of a strength training program that uses exclusively CKCE is unknown. In this study, we examined the effectiveness of CKCE vs. OKCE strength training programs in women enrolled in an introductory strength training program. Twenty-six participants were randomized to OKCE (traditional exercises) or CKCE (sling-based exercises). Participants completed 6 sets per week for 13 weeks. Pre and posttraining evaluations included the following: 1 repetition maximum (1RM) leg and bench press; sling exercise push-ups; isokinetic dynamometry; lateral step-down test; and the Star Excursion Balance Test. Both groups significantly improved bench press (by an average of 4–6 kg) and leg press (by an average of 23–35 kg) ( $p < 0.001$ ). There was a significant group  $\times$  time interaction ( $p < 0.001$ ) for sling exercise push-ups (OKCE pre = 5.5  $\pm$  8.6, OKCE post = 6.1  $\pm$  8.2, CKCE pre = 6.8  $\pm$  6.0, CKCE post = 16.9  $\pm$  6.6). Isokinetic measures of knee extension, knee flexion, shoulder internal rotation, and shoulder external rotation increased (improvements ranged from 2.7 to 27.7%), with no group differences. Both OKCE and CKCE strength training elicited similar changes in balance. We conclude that CKCE training is equally as effective as OKCE training during the initial phases of a strength training program in women. The fact that only CKCE improved sling exercise push-ups supports previous findings suggesting functional superiority of CKCE.

**KEY WORDS** closed-kinetic chain, open-kinetic chain, Redcord, 1RM, isokinetic dynamometry, balance



**Saeterbakken AH, Van Den Tillaar R, Seiler S.**

Effect of core stability training on throwing velocity in female handball players.

*The Journal of Strength and Conditioning Research* 2011;25(3):712-18

The purpose was to study the effect of a sling exercise training (SET)–based core stability program on maximal throwing velocity among female handball players. Twenty-four female high-school handball players (16.6 ± 0.3 years, 63.6 ± 6 kg, and 169.6 ± 7 cm) participated and were initially divided into a SET training group (n = 14) and a control group (CON, n = 10). Both groups performed their regular handball training for 6 weeks. In addition, twice a week, the SET group performed a progressive core stability-training program consisting of 6 unstable closed kinetic chain exercises. Maximal throwing velocity was measured before and after the training period using photocells. Maximal throwing velocity significantly increased 4.9% from 17.9 ± 0.5 to 18.8 ± 0.4 m·s<sup>-1</sup> in the SET group after the training period (p < 0.01), but was unchanged in the control group (17.1 ± 0.4 vs. 16.9 ± 0.4 m·s<sup>-1</sup>). These results suggest that core stability training using unstable, closed kinetic chain movements can significantly improve maximal throwing velocity. A stronger and more stable lumbopelvic-hip complex may contribute to higher rotational velocity in multisegmental movements. Strength coaches can incorporate exercises exposing the joints for destabilization force during training in closed kinetic chain exercises. This may encourage an effective neuromuscular pattern and increase force production and can improve a highly specific performance task such as throwing.

**KEY WORDS** strength, performance, unstable, closed kinetic



**Kim J, Gong W, Hwang B.**

The Effects of Resistivity and Stability-Combined Exercise for Lumbar Muscles on Strength, Cross-Sectional Area and Balance Ability: Exercises for Prevention of Lower Back Pain.

*Journal of Physical Therapy Science* 2011;23(2):247-50

**Purpose:** The purpose of this study was to investigate the effects of a resistance and stabilization complex exercise on the strength and cross-sectional area of lumbar muscles of typical adults in their twenties.

**Subjects and Methods:** For this study, 14 male adults in their twenties were chosen and randomly assigned to either the resistance exercise group (REG, n=7) or the resistance and stabilization exercise group (RSEG, n=7). They then exercised for 50 minutes three times a week for 8 weeks.

**Methods:** Pegasus was used to measure the strength of the lumbar muscles of the normal adults and computed tomography (CT) images were taken and compared to examine the changing cross-sectional areas of the lumbar muscles.

**Results:** Both groups showed a significant increase in the strength of their lumbar muscles. For the cross-sectional area of the lumbar muscles, only the superficial stabilizer muscle of the REG group showed a significant increase, whereas both the superficial stabilizer and the deep stabilizer muscles of the RSEG group showed a significant increase.

**Conclusion:** The resistance and stabilization complex exercise for the lumbar muscles had positive effects on both the strength of the lumbar muscles as well as on the cross-sectional areas of the superficial stabilizer and deep stabilizer muscles. Therefore, resistance and stabilization complex exercise appears to be an effective exercise program for the prevention of lower back pain.

**Key words:** Back pain, Resistance exercise, Lumbar stabilization exercise



**Ma SY, Je HD, Kim HD.**

A Multimodal Treatment Approach Using Spinal Decompression via SpineMED, Flexion-Distraction Mobilization of the Cervical Spine, and Cervical Stabilization Exercises for the Treatment of Cervical Radiculopathy.

*Journal of Physical Therapy Science* 2011;23(1):1-6

**Abstract.** [Purpose] The aim of the present study was to determine whether a multimodal treatment approach using spinal decompression via SpineMED and spinal mobilization as well as cervical stabilization exercises would benefit patients with neck pain with radiculopathy. [Subjects] A total of 10 patients with cervical radiculopathy ranging in age from 19 to 46 with an average age of 35.50 years participated in this study. [Methods] Patients received treatment in 85 minute sessions, 6 days per week for the first two weeks, and 4 days per week for two additional weeks. Treatment protocol consisted of spinal decompression via SpineMED and flexion-distraction mobilization of the cervical spine as well as cervical stabilization exercises. Physical therapy modalities including superficial heat, ultrasound, and interferential current were also delivered prior to administration of SpineMED. Differences between patients' pre-intervention and discharge outcome measures, pain on a visual analogue scale (VAS) and neck disability index (NDI), were examined using a paired t-test. [Results] Mean measures of patients' VAS and NDI demonstrated significant improvement after being treated with 20 sessions of combined treatment. [Conclusion] Findings of the present study provide significant evidence to support the efficacy of a multimodal treatment approach using spinal decompression via SpineMED and spinal mobilization as well as cervical stabilization exercises. A multimodal approach might be an asset in the management of cervical spine disorders.

**Key words:** Cervical radiculopathy, Spinal decompression, Multimodal treatment



**Muceli S, Farina D, Kirkesola G, Katch F, Falla D.**

Reduced force steadiness in women with neck pain and the effect of short term vibration.

*J Electromyogr Kinesiol* 2010;21(2):283-90

This study compares neck force steadiness in women with neck pain and controls and the way this is influenced by short term vibration of the neck. In the first experiment, 9 women with chronic neck pain and 9 controls performed 10-s isometric cervical flexion at 15 N. Intramuscular EMG was recorded from the sternocleidomastoid muscle. In the second experiment, 10 women with neck pain and 10 controls performed 10-s isometric cervical flexion at 25% of their maximal force before and after vibration to the neck (bursts of 50 Hz with duration 20, 40, 60 and 120 s). Surface EMG was acquired from the sternocleidomastoid and splenius capitis. In both experiments, force steadiness was characterized by the coefficient of variation (CoV) and the relative power in three frequency subbands (low: 0–3 Hz; middle: 4–6 Hz; high: 8–12 Hz) of the force signal. Women with neck pain exhibited decreased force steadiness (Exp 1: patients  $3.9 \pm 1.3\%$ , controls  $2.7 \pm 0.9\%$ ,  $P < 0.05$ ; Exp 2: patients  $3.4 \pm 1.2\%$ , controls  $1.7 \pm 0.6\%$ ,  $P < 0.01$ ) which was associated with higher power in the low-frequency band (patients  $71.2 \pm 9.6\%$ , controls  $56.7 \pm 9.2\%$ ,  $P < 0.01$ ). Following vibration, CoV ( $2.6 \pm 1.1\%$ ,  $P < 0.05$ ) and the power in the low-frequency band of the force signal decreased ( $63.1 \pm 13.9\%$ ,  $P < 0.05$ ) in the patient group. These effects were not present in controls. Motor unit behavior and surface EMG amplitude were similar between groups. In conclusion, women with neck pain have reduced force steadiness, likely due to alterations in Ia afferent input. Vibration, which modulates Ia afferent input, increases force steadiness in patients with neck pain.

Keywords: Neck pain, Steadiness, Vibration, Motor unit





**Saliba SA, Croy T, Guthrie R, Grooms D, Weltman A, Grindstaff TL.**

Differences in transverse abdominis activation with stable and unstable bridging exercises in individuals with low back pain.

*North American Journal Of Sports Physical Therapy* 2010;5(2):63-73

**Background.** The transversus abdominis (TrA) is a spine stabilizer frequently targeted during rehabilitation exercises for individuals with low back pain (LBP). Performance of exercises on unstable surfaces is thought to increase muscle activation, however no research has investigated differences in TrA activation when stable or unstable surfaces are used.

**Objective.** The purpose of this study was to investigate whether TrA activation in individuals with LBP is greater when performing bridging exercises on an unstable surface versus a stable surface.

**Methods.** Fifty one adults (mean  $\pm$  SD, age  $23.1 \pm 6.0$  years, height  $173.60 \pm 10.5$  cm, mass  $74.7 \pm 14.5$  kg) with stabilization classification of LBP were randomly assigned to either exercise progression utilizing a sling bridge device or a traditional bridging exercise progression, each with 4 levels of increasing difficulty. TrA activation ratio (TrA contracted thickness/TrA resting thickness) was measured during each exercise using ultrasound imaging. The dependent variable was the TrA activation ratio.

**Results.** The first 3 levels of the sling-based and traditional bridging exercise progression were not significantly different. There was a significant increase in the TrA activation ratio in the sling-based exercise group when bridging was performed with abduction of the hip ( $1.48 \pm .38$ ) compared to the traditional bridge with abduction of the hip ( $1.22 \pm .38$ ;  $p < .05$ ).

**Conclusion.** Both types of exercise result in activation of the TrA, however, the sling based exercise when combined with dynamic movement resulted in a significantly higher activation of the local stabilizers of the spine compared to traditional bridging exercise. This may have implications for rehabilitation of individuals with LBP

**Key Words.** Core stability, rehabilitation, Rehabilitative, Ultrasound Imaging



**Ma SY, Kim HD.**

The Efficacy of Spinal Decompression via DRX3000 combined with a Spinal Mobilization and a Lumbar Stabilization Exercise Program for Patients with Discogenic Low Back Pain.

*Journal of Physical Therapy Science* 2010;22(4):345-54

**Abstract.** [Purpose] The purpose of this study was to determine the effects of motorized spinal decompression using the DRX3000 system (Axiom Worldwide, Tampa, FL, USA) combined with spinal mobilization as well as lumbar stabilization exercises on patients with discogenic low back pain (LBP). [Subjects] A total of 30 adults with discogenic LBP (mean age,  $34.06 \pm 6.41$  years; age range, 28–48 years; 14 males, 16 females) volunteered to participate in this study. [Methods] A 4-week course of spinal decompression treatment combined with motorized flexion-distraction mobilization and lumbar stabilization exercises were administered to the participants for 6 days per week for the first two weeks, and four times per week for two additional weeks. The entire treatment consisted of 20 visits over a 4-week period. Comparisons of changes in the Oswestry Disability Index (ODI) and straight leg raise (SLR) test at pre-intervention, after 10 treatment sessions, and at discharge (after 20 treatment sessions) were analyzed. [Results] There were significant improvements in the outcome measures of ODI score and SLR test after 10 and 20 sessions of spinal decompression treatment combined with spinal mobilization and lumbar stabilization exercises as compared with the pre-intervention. [Conclusion] Spinal decompression treatment combined with spinal mobilization and lumbar stabilization exercises significantly improved the clinical outcome measures of ODI score and SLR test in patients with LBP secondary to intervertebral disc herniation.

**Key words:** Low back pain, Spinal decompression therapy, Spinal mobilization



**Foss P, Orpana A, Foss AM.**

"Rehabilitation of people with fibromyalgia – short and long term effects".

*Fibromyalgiblad* 2010;2:18-24

The article is available only in Norwegian.

**Burkert C.**

Wie hilft Neurac bei Rückenschmerzen.

*Praxis Physiotherapie* 2010;3:176-82

The article is available only in German.

**Burkert C.**

Unspezifische lumbale Rückenschmerzen.

*Zeitschrift für Physiotherapeuten* 2010;62(9):51-6

The article is available only in German.



**Unsgaard-Tøndel M, Fladmark AM, Salvesen Ø, Vasseljen O.**

Motor Control Exercises, Sling Exercises, and General Exercises for Patients With Chronic Low Back Pain: A Randomized Controlled Trial With 1-Year Follow-up.

*Physical Therapy* 2010;90(10):1426-40

**Background.** Exercise benefits patients with chronic nonspecific low back pain; however, the most effective type of exercise remains unknown.

**Objective.** This study compared outcomes after motor control exercises, sling exercises, and general exercises for low back pain.

**Design.** This was a randomized controlled trial with 1-year follow-up. Setting. The study was conducted in a primary care setting in Norway.

**Patients.** The participants were patients with chronic nonspecific low back pain (n\_109).

**Interventions.** The interventions in this study were low-load motor control exercises, high-load sling exercises, or general exercises, all delivered by experienced physical therapists, once a week for 8 weeks.

**Measurements.** The primary outcome measure was pain reported on the Numeric Pain Rating Scale after treatment and at a 1-year follow-up. Secondary outcome measures were self-reported activity limitation (assessed with the Oswestry Disability Index), clinically examined function (assessed with the Fingertip-to-Floor Test), and fear-avoidance beliefs after intervention.

**Results.** The postintervention assessment showed no significant differences among groups with respect to pain (overall group difference) or any of the outcome measures. Mean (95% confidence interval) group differences for pain reduction after treatment and after 1 year were 0.3 (-0.7 to 1.3) and 0.4 (-0.7 to 1.4) for motor control exercises versus sling exercises, 0.7 (-0.6 to 2.0) and 0.3 (-0.8 to 1.4) for sling exercises versus general exercises, and 1.0 (-0.1 to 2.0) and 0.7 (-0.3 to 1.7) for motor control exercises versus general exercises.

**Limitations.** The nature of the interventions made blinding impossible.

**Conclusions.** This study gave no evidence that 8 treatments with individually instructed motor control exercises or sling exercises were superior to general exercises for chronic low back pain.



**Vasseljen O, Flademark AM.**

Abdominal muscle contraction thickness and function after specific and general exercises: A randomized controlled trial in chronic low back pain patients.

*Manual Therapy* 2010;15:482-9

The aim of this study was to assess changes in deep abdominal muscle function after 8 weeks of exercise in chronic low back pain patients. Patients (n = 109) were randomized to specific ultrasound guided, sling or general exercises. Contraction thickness ratio in transversus abdominis (TrA), obliquus internus (OI) and externus (OE), and TrA lateral slide were assessed during the abdominal drawing-in maneuver by b-mode ultrasound. Changes in abdominal muscle function were also regressed on changes in pain. Only modest effects in deep abdominal muscle function were observed, mainly due to reduced activation of OI (contraction thickness ratio: 1.42e1.22, p = 0.01) and reduced TrA lateral slide (1.26e1.01 cm, p = 0.02) in the ultrasound group on the left side. Reduced pain was associated with increased TrA and reduced OI contraction ratio (R<sup>2</sup> = 0.18). It is concluded that 6e8 treatments with specific or general exercises for chronic low back patients attained only marginal changes in contraction thickness and slide in deep abdominal muscles, and could only to a limited extent account for reductions in pain.

Keywords: Exercise, LBP, Abdominal muscles, Thickness



**Kirkesola G.**

Neurac – a new treatment method for chronic musculoskeletal pain.

Tidsskriftet Fysioterapeuten 2009;76(12):16-25

The effect of exercise therapy on chronic musculoskeletal pain is generally low and moderate at best. In this paper a new exercise treatment method, Neurac, is described with theoretical background, development, main content, and documentation.

Neurac is a treatment method that aims at regaining normal functional movement patterns in patients with musculoskeletal disorders, by using high levels of neuromuscular stimulation

This is an active treatment approach including four main elements: 1. Bodyweightbearing exercises utilizing the Redcord sling system, 2. Controlled vibration to selected body parts, 3. Gradual increase of resistance (work-load), 4. No pain or no increase of existing pain.

A newly developed vibration apparatus, Redcord Stimula, is often used to augment neural adaptations by a potential increase in activation of muscle spindles. The Neurac method also includes testing procedures for neuromuscular function of the kinetic chains, and the integration of «local» and «global» muscle function.

Theoretically, Neurac is based on supporting research on bodyweightbearing exercises loading the biomechanical chains. Further, based on neuroscience and clinical trials the method utilizes vibration to increase neural drive and to decrease pain.

The development of the Neurac-methodology has emerged from the S-E-T concept (Sling Exercise Therapy). The new methodology involves use of the Redcord Trainer (formerly called TerapiMaster), workstation and the vibration apparatus.

Documentation: Systematic observations in the clinic show changes after implementation, but research is needed to evaluate the efficiency of the Neurac-method as a physiotherapeutic tool.

**Key Words:** Musculoskeletal pain, Neuromuscular function, Neurac, Redcord, Vibration, Physical therapy modality, Physical therapy speciality



**Kuszewski M, Gnat R, Saulicz.**

Stability training of the lumbo-pelvo-hip complex influence stiffness of the hamstrings: a preliminary study.

*Scand J Med Sci Sports* 2009;19:260-6

**Abstract**

An analysis of data obtained in an experiment investigating the influence of stability training of the lumbo-pelvo-hip complex (LPHC) on stiffness of the hamstrings is presented. Randomized controlled trial. The study included 30 subjects (aged 18–42 years) with increased stiffness of the hamstrings at baseline. Over a period of 4 weeks, stability training aiming to activate the deep stabilizing muscle subsystem and to integrate its action with the superficial subsystem was introduced in the experimental group. The control group remained unaffected. Three series of measurements were applied (baseline, after 2 weeks, and after 4 weeks). A digital inclinometer was used to measure outcomes of passive knee extension in the supine test. In the experimental group, a tendency to decrease stiffness of the hamstrings was observed. It was the opposite in the control group. Significant intra-group differences in the experimental group between series 1 and 3 measurements for both the right and left lower extremities were revealed. Stability training of the LPHC showed a tendency to be effective in reducing stiffness of the hamstrings.



**Prokopy, MP, Ingersoll, CD, Nordenschild, E, Katch, FI, Gaesser GA, Weltman A.**

Closed-kinetic chain upper-body training improves throwing performance of NCAA Division I Softball players.

Journal of Strength and conditioning 2008;22(6):1790-8

Closed-kinetic chain resistance training (CKCRT) of the lower body is superior to open-kinetic chain resistance training (OKCRT) to improve performance parameters (e.g., vertical jump), but the effects of upper-body CKCRT on throwing performance remain unknown. This study compared shoulder strength, power, and throwing velocity changes in athletes training the upper body exclusively with either CKCRT (using a system of ropes and slings) or OKCRT. Fourteen female National Collegiate Athletic Association Division I softball player volunteers were blocked and randomly placed into two groups: CKCRT and OKCRT. Blocking ensured the same number of veteran players and rookies in each training group. Training occurred three times weekly for 12 weeks during the team's supervised off-season program. Olympic, lower-body, core training, and upper-body intensity and volume in OKCRT and CKCRT were equalized between groups. Criterion variables pre- and posttraining included throwing velocity, bench press one-repetition maximum (1RM), dynamic single-leg balance, and isokinetic peak torque and power (PWR) (at 180°/s) for shoulder flexion, extension, internal rotation, and external rotation (ER). The CKCRT group significantly improved throwing velocity by 2.0 mph (3.4%,  $p < 0.05$ ), and the OKCRT group improved 0.3 mph (0.5%, NS). A significant interaction was observed ( $p < 0.05$ ). The CKCRT group improved its 1RM bench press to the same degree (1.9 kg) as the OKCRT group ( $p < 0.05$  within each group). The CKCRT group improved all measures of shoulder strength and power, whereas OKCRT conferred little change in shoulder torque and power scores. Although throwing is an open-chain movement, adaptations from CKCRT may confer benefits to subsequent performance. Strength coaches can incorporate upper-body CKCRT without sacrificing gains in maximal strength or performance criteria associated with an athletic open-chain movement such as throwing.

**KEY WORDS** resistance training, open-kinetic chain, shoulder peak torque, shoulder power





**Marovino T.**

Neuromuscular Training In Pain Management.

*Practical PAIN MANAGEMENT* 2008;8(9):66-9

Re-activation of deep local stabilizing muscles of the spine has been demonstrated to be an essential part of rehabilitation for the musculoskeletal system and, in particular, mechanical spine pain.

How many people would think of using some form of exercise as primary pain management? If you're the typical practitioner who perhaps doesn't get the opportunity to read the latest research in the sport sciences, you might answer, "Not many." In this clinical report, I would like to draw attention to the increasing body of research appearing in both the strength/conditioning and pain therapy realms that is providing evidence for lumbo-pelvic core stabilization training as a method to restore normal function while, at the same time, reducing spinal pain. There is still continuing debate as to which specific methods are the best, but a general consensus is forming regarding the presence of a muscle impairment component to many of the mechanical/ idiopathic low back pain syndromes being seen by practitioners today.<sup>1</sup> The phrase 'core stabilization training' has become popular and somewhat in vogue with trainers and therapists alike. Stabilization is not the same as strengthening yet many practitioners continue to use the terms synonymously. The Redcord method of core stabilization was developed in Norway in the 1990s and represents one of the most popular techniques for specific core stabilization treatment through neuromuscular re-activation (neurac). We will begin our discussion with semantic clarifications while examining the main premise behind Redcord therapy.



**Tsauo JY, Cheng PF, Yang RS.**

The effects of sensorimotor training on knee proprioception and function for patients with knee osteoarthritis: a preliminary-report.

Clin Rehabil 2008;22;448-57

**Objective:** To investigate the effects of a sensorimotor training programme in osteoarthritic patients.

**Design:** Randomized, single-blind, controlled trial.

**Setting:** Kinesiology laboratory at School of Physical Therapy.

**Participants:** A total of 60 patients were randomly assigned to the training group and the control group. Only 29 patients (training group, 15; control group, 14) completed the study.

**Intervention:** The training group underwent a sensorimotor training programme using a sling suspension system complemented by a routine physical therapy. The control group underwent a routine physical therapy.

**Main measures:** Active joint repositioning, functional testings, and self-reported function with the Western Ontario & McMaster Universities Arthritis Index before and after the eight-week intervention.

**Results:** There were significant differences between the two groups with respect to the improvement in proprioception as measured by active joint repositioning (the changes in the absolute error were 1.91.7, training group versus 0.12.8, control group (P50.05), and in self-reported functional difficulty (33.235.1, training group versus 8.010.2, control group; P50.05)). There was no significant difference between the two groups in other outcomes.

**Conclusion:** A sensorimotor training using a sling suspension system improved the patients' proprioception in the knee joints and their self-reported function. Thus, these exercises may serve as an exercise programme for patients with knee osteoarthritis.



**Schmoll S, Hahn D, Schwirtz A.**

Die Behandlung von chronischen LWS-Smerz mithilfe des S-E-T-Konzeptes (Sling-Exercise-Therapy).

*Bewegungstherapie und Gesundheitssport* 2008;24:1-8.

English title: Treatment of low back pain and effectiveness of Sling-Exercise-Therapy (S-E-T).

An experimental study was carried out to compare S-E-T-Training versus conventional strength-training regarding their effectiveness in the therapy of low back pain. The parameters of interest were maximum strength of the trunk muscles (flexion/extension), spine stabilization, pain intensity and general well-being. The S-E-T Training method proved to be highly effective in improving trunk-stabilization. There were no significant differences concerning the maximum strength. Both training groups were able to reduce their pain intensity and increase their general well-being.

**Key words:** Chronic low back pain, therapy, Sling-exercise-Therapy

The article is only available in German.



**Vestergaard S, Puggaard L, Kronborg C.** Træning/genoptræning at ældre – tre projekter I et sundhedsøkonomisk perspektiv. Syddansk Universitet 2007

The article is only available in Danish.



**Vikne J, Oedegaard A, Laerum E, Ihlebaek C, Kirkesola G.**

A randomized study of new sling exercise treatment vs traditional physiotherapy for patients with chronic whiplash-associated disorders with unsettled compensation claims.

*J.Rehabil Med* 2007;39(3):252-9

**BACKGROUND:** Many patients with chronic whiplash-associated disorders have reduced neuromuscular control of the neck and head. It has been proposed that a new sling exercise therapy may promote neuromuscular control of the neck.

**OBJECTIVES:** To compare the effects of traditional physiotherapy vs traditional physiotherapy combined with a new sling exercise therapy on discomfort and function in patients with chronic whiplash-associated disorders who have unsettled compensation claims; and to investigate possible additional effects of guided, long-term home training.

**DESIGN:** A randomized multi-centre trial with 4 parallel groups.

**METHODS:** A total of 214 patients were assigned randomly to 4 treatment groups, and received either traditional physiotherapy with or without home training, or new sling exercise therapy with or without home training. Outcome measures were pain, disability, psychological distress, sick leave and physical tests.

**RESULTS:** A total of 171 patients (80%) completed the study. There were no important statistical or clinical differences between the groups after 4 months of treatment. There was a small statistically significant effect at 12-month follow-up in both groups with home training regarding pain during rest ( $p = 0.05$ ) and reported fatigue in the final week ( $p = 0.02$ ).

**CONCLUSION:** No statistically significant differences were found between the traditional physiotherapy group and the new sling exercise group, with or without home training. Since the groups were not compared with a control group without treatment, we cannot conclude that the studied treatments are effective for patients with whiplash-associated disorder, only that they did not differ in our study.



**Stray Pedersen JI, Magnussen R, Kuffel E, Seiler S.**

Sling Exercise Training improves balance, kicking velocity and torso stabilization strength in elite soccer players.

*Medicine & Science in Sports & Exercise* 2006;38(5):243

**Purpose:** To determine the impact of a Sling Exercise Training (SET) core stability program on postural balance, kicking velocity, functional strength, and back pain in elite level soccer players.

**Method:** 12 Norwegian 1<sup>st</sup> division soccer players completed 8 wk x 2 d<sup>wk</sup><sup>-1</sup> SET training with a main focus on the hip and trunk area. Each training session, athletes performed 8 different highly unstable, closed kinetic chain exercises in adjustable slings. Exercise difficulty was progressed by increasing the resistance arm and degree of instability. 4 of the training group had suffered extended periods of low back pain. 9 players of similar performance level served as a control group.

**Results:** Balance: Mean one-legged eyes closed COP sway velocity moment decreased 45 % in the worst leg ( $p < 0.01$ ) and 18% in the best leg ( $p = 0.113$ ). The mean difference in velocity moment between the legs was reduced from 51% to 3% ( $p=0.001$ ). No change in balance performance was observed in the control group. Kicking: Ball velocity during one-step maximal velocity kicking (preferred leg) increased significantly in the training group (3.5%,) compared to controls (-2.3 %,  $p = 0,04$ ). Torso functional strength: The 4 subjects with chronic low back all reported that pain was reduced after training. The training group, and particularly chronic low back pain subjects, significantly improved in a clinical test of pelvic rotational stability ( $p < 0.01$ , see *picture of test condition*).

**Conclusion:** This unique functional stability training program involving movements performed in unstable slings clearly improved static balance and reduced low back pain. In addition, a small but significant improvement in kicking performance was observed. To our knowledge this is the first study to demonstrate a direct performance enhancing effect of a core stability training program. Functional strength training in slings appears to be an effective modality for enhancing neuromuscular control and joint stability.



**Seiler S, Skaanes PT, Kirkesola G.**

Effects of Sling Exercise Training on maximal clubhead velocity in junior golfers.

*Medicine & Science in Sports & Exercise* 2006;38(5):286

**Purpose:** To determine the impact of a Sling Exercise Training (SET) core stability program on maximal club-head velocity in competitive junior golf players.

**Methods:** 2 teams of junior golfers (SET 15±2 yr 13 handicap, CON 15.8 yr 6 handicap) performed either 9 wks x 2 wk<sup>-1</sup> specific core and rotational stability training (SET, n=10), or standard strength training 2 wk<sup>-1</sup> (CON, n=10). Maximal club-head velocity was measured over 10 trials before and after the intervention period using a dedicated velocity measurement system system.

**Results:** Preliminary within-days learning effects trials showed very stable stroke to stroke velocity (CV 1.6%). Between days (~7 days) reliability for maximal club-head velocity was also excellent (r= 0.99, mean diff= 0.1 m sec<sup>-1</sup>). Baseline performance was similar in both groups (SET 42.1±4.1 m s<sup>-1</sup>, CON 42.7±5.7 m s<sup>-1</sup>). However, at post-test SET increased club head velocity 3.8% (95% CI 2.6-4.8%, p< 0.001) compared to 1.2% in CON (95% CI 0.0-1.0%, p=0.05). Standing balance in the golf swing position was also measured using a computerized balance platform. However, no significant balance changes were observed in either group.

**Conclusions:** A unique functional stability program consisting of progressively unstable, closed kinetic chain exercises for the hips and torso appears to improve rotational power in a highly specific performance task. The magnitude of the improvement (Effect Size= 0.4) is small but meaningful from a performance standpoint (equivalent to 10-15m increase in drive distance). This is to our knowledge one of the first studies to demonstrate a transfer of generalized core stability training to a specific performance task.



**Brage S, Lærum E, Herland K.**

The effect and experiences by implementing the sling training concept "S-E-T Corporate" in Norwegian IA companies.

Unpublished, 2005.

The purpose of the study to evaluate implementing S-E-T Corporate in a number of Norwegian companies and to compare this intervention to other traditional physiotherapeutic interventions. The study lasted for 12 months and was initiated in March 2003. Participants in the intervention group (80 employees in 6 companies) training S-E-T obtained a significant improvement in functional ability and self reported physical health. In the control group (37 employees in 4 companies) there were no improvements in the functional ability and self reported health. There was no significant decrease in sick leave in either of the two groups but in some companies which had a high sick leave prior to project there were reductions in sick leave after implementing S-E-T. What seemed to be the "common factor" in the companies that did get a reduction in sick leave was encouraged company leadership and encouraged physiotherapist with a good S-E-T knowledge.





**Stuge B, Lærum E, Kirkesola G, Vøllestad N:**

The Efficacy of a Treatment Program Focusing on Specific Stabilizing Exercises for Pelvic Girdle Pain After Pregnancy. A Randomized Controlled Trial.

*SPINE* 2004;29(4):351-9.

**Study Design.** A randomized controlled trial with stratified block design.

**Objectives.** To evaluate a treatment program focusing on whether specific stabilizing exercises for patients with pelvic girdle pain after pregnancy reduce pain, improve functional status, and improve quality of life.

**Summary of Background Data.** The evidence of effectiveness of treatment for pelvic girdle pain is weak. Recent research has focused on the importance of activation of muscles for motor control and stability of the lumbopelvic region. To the authors' knowledge, the efficacy of applying these principles for pelvic girdle pain has not previously been evaluated in a randomized controlled trial.

**Methods.** Eighty-one women with pelvic girdle pain were assigned randomly to two treatment groups for 20 weeks. One group received physical therapy with a focus on specific stabilizing exercises. The other group received individualized physical therapy without specific stabilizing exercises. Assessments were administered by a blinded assessor, at baseline, after intervention and 1 year post partum. Main outcome measures were pain, functional status and quality of life.

**Results.** There were no dropouts. After intervention and at 1 year post partum, the specific stabilizing exercise group showed statistically and clinically significant lower pain intensity, lower disability, and higher quality of life compared with the control group. Group difference in median values for evening pain after treatment was 30 mm on the Visual Analog Scale. Disability was reduced by more than 50% for the exercise group; changes were negligible in the control group. Significant differences were also observed for physical tests, in favor of the specific exercise group.

**Conclusion.** An individualized treatment approach with specific stabilizing exercises appears to be more effective than physical therapy without specific stabilizing exercises for women with pelvic girdle pain after pregnancy.

Key words: pelvic girdle pain, postpartum, randomized controlled trial, physical therapy, specific stabilizing exercises, effectiveness



**Stuge B, Veierød M B, Lærum E, Vøllestad N.**

The Efficacy of a Treatment Program Focusing on Specific Stabilizing Exercises for Pelvic Girdle Pain After Pregnancy. A Two-Year Follow-up of a Randomized Clinical Trial.

*SPINE* 2004;29(10):E197-203

**Study Design.** A randomized clinical trial.

**Objectives.** To examine the effects of a treatment program focusing on specific stabilizing exercises after a 2-year follow-up period.

**Summary of Background Data.** An individualized treatment approach with specific stabilizing exercises is shown to be effective for women with pelvic girdle pain 1 year after delivery. No previous study has examined the long-term effects of treatment for women with postpartum pelvic girdle pain.

**Methods.** Eighty-one women with pelvic girdle pain postpartum were assigned randomly to 2 treatment groups for 20 weeks. Patient self-reported questionnaires measuring pain, disability, and health-related quality of life were collected after 20 weeks of treatment and 1 and 2 years postpartum.

**Results.** All 81 women returned the questionnaires for the 2-year follow-up. Sixteen were excluded from the analysis, mainly due to new pregnancies. The significant differences between the groups in functional status, pain, and physical health (SF-36) were maintained 2 years after delivery. Minimal disability was found in 85% of the specific stabilizing exercise group as compared to 47% in the control group. The control group showed significant improvement in functional status with median change score of 6.0 (Q1–Q3 of 12–0). Minimal evening pain was reported by 68% in the specific stabilizing exercise group versus 23% in the control group. However, the group differences disappeared for all measures when controlling for score level 1 year after delivery by regression analysis.

**Conclusion.** The significant differences between the groups persisted with continued low levels of pain and disability in the specific stabilizing exercise group 2 years after delivery. Significant reduction in disability was found within the control group. Those with the highest level of disability and greatest potential for improvements recovered most, regardless of intervention group.

Key words: pelvic girdle pain, postpartum, randomized controlled trial, physical therapy, specific stabilizing exercises, effectiveness, follow-up



## **Øderud T.**

Pilot project – Active rehabilitation and training of the elderly. Implemented 2000 – 2001.

*SINTEF Unimed NIS Health and Rehabilitation 2001 (A 50 page report)*

### **Summary**

Nordisk Terapi AS, SINTEF Health Research, selected key professionals and three municipalities, Arendal, Bærum and Lunner, have carried out the pilot project “Active rehabilitation and training of elderly people”. The Norwegian Industrial and Regional Development fund (SND) has supported the project. During the pilot project we have:

- Investigated the needs for active rehabilitation and training of elderly people in connection with fractures, brain strokes and other chronic conditions
- Established co-operation between the health care sector, industry and research institutes as well as contact with the National Insurance Administration (RTV)
- Carried out seven basic training courses for professionals on the use of TerapiMaster
- Worked out a project proposal for the development of new concepts for active rehabilitation for elderly people based on S-E-T (Sling Exercise Therapy)

Traditionally there has been a lack of resources in the rehabilitation field, but now the need for development in the rehabilitation field seems to be recognised. Professionals emphasise that rehabilitation must be a priority because rehabilitation represents an investment in future possibilities and results. The parliamentary document on rehabilitation and subsequent follow-up shows that the Norwegian authorities are working towards increased focus on rehabilitation and in particular the users' own active participation in the process.

Co-operation across services is vital, giving the elderly a holistic rehabilitation process, starting off with surgery, moving on to treatment in the nursing home, training in the physiotherapy clinic and finally transfer to the users home. Such a complete concept, combined with thorough user training is important in order to feel safe and motivated for making the effort to exercise. The complete concept depends on close co-operation between all involved parties, mainly nursing staff and physiotherapists. In Lunner municipality, the pilot project has showed how using TerapiMaster can be a link between different health care services thus exchanging professional points of view and improving collaboration in the rehabilitation process.

The pilot project, in particular the investigation into needs, and the parliamentary document, points out the need for further training and follow-up of health service personnel. Furthermore there is a need for a long-term strategy on development of expertise and research in the rehabilitation field. It is also evident that there is a need for better documentation regarding the benefits and effect of alternative rehabilitation methods. The results of active training must be documented and made public to the users themselves, to professionals, local health care services and the authorities. Practical examples of cost/effect analysis indicate that a reasonable investment such as S-E-T with TerapiMaster combined with training and active follow-up can increase functional ability and quality of life thus representing a saving for society by means of reduced costs in connection with various forms of care. Health care personnel have responded with many positive experiences using the S-E-T concept and TerapiMaster in connection with treatment and training together with patients and also as a means to relieve the therapist.

The summary states: “Practical examples of cost-benefit analyses indicate that a reasonable investment such as S-E-T using the TerapiMaster combined with instruction and active follow-up, can increase the level of functioning and quality of life and save society considerable outlays for institutionalization and care.”

An article about this project appeared in Geriatrix.

This report is available only in Norwegian.



**Kirkesola G.**

Sling Exercise Therapy – S-E-T. A concept for active treatment and training for ailments in the musculoskeletal apparatus.

Tidsskriftet Fysioterapeuten 2000;12:9-16.

Sling Exercise Therapy (S-E-T) is a total concept for active treatment and exercise with the aim of contributing to permanent improvement of musculoskeletal disorders. The model is based on what are assumed to be the key elements of active training and rehabilitation today (which are described and documented in this article). The concept, which has been developed in Norway over the past eight years, is also used in the treatment of strokes and other neurological conditions, for stimulating children and for fitness training. This article focuses on treatment of musculoskeletal disorders. The S-E-T concept consists of a system of diagnosis and treatment. The system of diagnosis involves testing of the muscles' tolerance through progressive loading in open and closed kinetic chains, and is used together with conventional examinations in diagnosing musculoskeletal disorders. The treatment system contains elements such as relaxation, increasing the range of movement, traction, training the stabilizing musculature, sensorimotor exercises, training in open and closed kinetic chains, dynamic training of the mobilizing musculature, fitness training, group exercise, personal exercise at home with long-term follow-up, and computer software for setting up and modifying exercises. The concept has been developed in the light of current knowledge regarding active treatment and exercise for musculoskeletal disorders. Although clinical experience with the S-E-T concept has been positive, there is a lack of scientific evidence. Therefore research has been heavily emphasized. A randomized study of the effect of personal exercise at home on chronic back pain and a pilot study of the effect of active treatment and personal exercise at two companies in Norway have been published. A randomized study on the treatment of Whiplash Associated Disorders was implemented in 1999. During the current year studies on the effect of training of the elderly, on the effect of active treatment and exercise at the workplace combined with home exercise, exercises in the treatment of unstable shoulders and training of athletes will be initiated.

This article was also published in Krankengymnastik, Germany in March 2001.



**Moe K, Thom E.**

The effect of regular exercise on absenteeism due to illness. Results of an intervention study.

*Tidsskriftet Fysioterapeuten* (Special Issue), December 2001

The background for this prospective not-randomized study was to evaluate if regular training can reduce sick leave for employees having musculoskeletal problems. 33 employees (14 women / 19 men) in two Norwegian industrial companies, having shoulder, neck and back problems, participated in 12 month period. The Norwegian developed S-E-T concept was used as training intervention.

The S-E-T (Sling Exercise Therapy) program consisted of regular relaxation exercises performed at the workplace, and individual training at home three times per week. The training program was developed by an experienced physiotherapist. Results from the study showed that relaxation and physical training, in combination with follow-up and assistance by a physiotherapist, can significantly reduce the sick leave for employees have musculoskeletal problems.

33 employees of two Norwegian industrial enterprises with neck, shoulder and back problems reduced their specific absenteeism by a total of 558 days, i.e. 14.7 days per man-year, which amounted to 80% of the absenteeism due to musculoskeletal ailments. Total absenteeism was reduced by 437 days, i.e. 11.5 days per man-year. This reduction was sustained the year after the intervention.

The article is only available in Norwegian.



**Moe K, Thom E.**

Musculoskeletal disorders and physical activity. Results of a long-term study.

*Tidsskriftet for Den norske Lægeforening 1997;29:4258-61*

In two Norwegian industrial companies, 42 employees (24 female / 18 male) with shoulder, neck and back problems, took part in a training program over a 12-month period. The program comprised daily relaxation exercises at work combined with training at home for about 30 minutes three times a week. The Norwegian-designed physiotherapy and training apparatus, TerapiMaster, was used both at work and at home. The training program was developed and monitored by an experienced physiotherapist

The observations made during the training program focused on changes in the rate of absence due to illness during the study compared with the pre-study rate of absence due to illness.

For employees with musculo-skeletal ailments, the combination of relaxation exercises and physical training, with professional instruction and follow-up, significantly reduced the rate of absence due to illness from 11,2 days per year (Pre-study) to 0,2 days per year (at the end of the 12-month training period) ( $p < 0,001$ )

A follow-up 30 months after completion of the formal study showed that absence due to illness had remained at the reduced rate, probably because positive experiences and 'good habits' formed during the study encouraged the participants to continue the training program

The article is only available in Norwegian.



**Ljunggren AE, Weber H, Kogstad O, Thom E, Kirkesola G.**

Effect on sick leave due to low back pain. A randomized, comparative, long-term study.

*SPINE* 1997;22:1610-6

**Study Design.** The study was carried out as an open randomized, multicenter, parallel-group study with an observation period of 12 months. Four Norwegian physiotherapy institutes took part. Patients were subsequently followed for 12 months of home exercise on their own, without the supervision of a physiotherapist.

**Objectives.** 1) To investigate and compare the effects of two different exercise programs on low back problems in patients after a 1-year training program under the supervision of a physiotherapist. 2) To investigate the effect supervision by, and motivation from, physiotherapists has on training compliance and efficacy.

**Summary of Background Data.** After ordinary physiotherapy treatment for low back problems, patients were randomly allocated either to a conventional training program designed by physiotherapists or to a training program using a new Norwegian-developed training apparatus called the TerapiMaster. The study included 153 patients with low back problems, all of whom had been referred to physiotherapy by their general practitioners. One hundred twenty-six patients were followed for an additional 12 months when performing home exercise programs on their own

**Methods.** Monitoring patient satisfaction with the training program, compliance with the program, and absenteeism from work during the training period.

**Results.** Patient satisfaction with both training programs was high, with about 83% of participating patients completing the study in accordance with the protocol. Mean absenteeism (SD) during the preceding year totaled 82,5 days(19,8) in the conventional training group and 61,6 days (14,7) in the TerapiMaster group. Significant reductions to 17,2 days (6,0) and 15,4 days (5,3) in the two groups, respectively, were recorded during the training period, corresponding to a 75% to 80% reduction compared with the preceding 1-year period. Mean absenteeism showed a further significant decline during the 12-month period without supervised training. The average values were 9,9 days (3,2) for conventional training and 9,3 days (3,1) for the TerapiMaster, respectively.

**Conclusion.** Both exercise programs reduced absenteeism significantly (75-80%). No difference in the effects of the two different programs was discernible. Regular follow-up through encouragement and variation in the training programs appear to be important factors for motivating patients to adhere to regular exercise programs for low back problems. This thesis was corroborated by the 12-month study of unsupervised exercise.