



## Publications involving Redcord



1. **Kim, S., Salazar Fajardo, J. C., & Yoon, B. (2023).** Activation of Anterolateral Abdominal Muscles During Sling Bridge Exercises: Comparison of Different Pelvic Positions. *Journal of sport rehabilitation*, 1–9. Advance online publication. <https://doi.org/10.1123/jsr.2022-0216>
2. **Yan, Z. W., Yang, Z., Zhao, F. L., Gao, Y., Wu, Z. K., Wang, J. L., & Zhou, M. (2022).** Effect of sling exercise therapy on surface electromyography and muscle thickness of superficial cervical muscle groups in female patients with chronic neck pain. *Journal of back and musculoskeletal rehabilitation*, 10.3233/BMR-220030. Advance online publication. <https://doi.org/10.3233/BMR-220030>
3. **Biały, M., Kublin, K., Brzuszkiewicz-Kuźmicka, G., & Gnat, R. (2022).** Myofascial and Movement Tests after Anterior Cruciate Ligament Reconstruction. *Journal of human kinetics*, 83, 67–75. <https://doi.org/10.2478/hukin-2022-0052>
4. **Mun D.-J., Oh H.-J., & Lee S.-H. (2022).** Effects of Sling Exercise on Pain, Trunk Strength, and Balance in Patients with Chronic Low Back Pain. *J Kor Phys Ther.* 34(3):110-115. <https://doi.org/10.18857/jkpt.2022.34.3.110>
5. **Liu, Q., Zhu, C. & Huang, Q.** Effects of sling exercise on the core endurance and performance of basketball players. *Revista Brasileira de Medicina do Esporte*, 2022; 29.
6. **Li, X., Zhang, H., Lo, W., Ge, L., Miao, P., Liu, H., Li, L., & Wang, C.** Sling Exercise Can Drive Cortical Representation of the Transversus Abdominis and Multifidus Muscles in Patients With Chronic Low Back Pain. *Frontiers in neurology*, 2022; 13, 904002. <https://doi.org/10.3389/fneur.2022.904002>
7. **Wang, J., Wang, S., Wu, H., Dong, S., & Zhang, B.** Muscle Energy Technique plus Neurac Method in Stroke Patients with Hemiplegia Complicated by Diabetes Mellitus and Assessment of Quality of Life. *Disease markers*, 2022, 6318721. <https://doi.org/10.1155/2022/6318721>
8. **Michalíková, M., Bednarčíková, L., Ondrejová, B., Barcalová, M., & Živčák, J.** Effect of Neurac Therapy on plantar pressures distribution and the center of gravity of the human body. *Acta Technologia*, 2021;7(4):121-124
9. **Song, E. J., Lee, E. J., & Kwon, H. Y.** The effects of sling exercise program on balance and body activities in children with spastic cerebral palsy. *Journal of exercise rehabilitation*, 2021; 17(6), 410–417. <https://doi.org/10.12965/jer.2142608.304>
10. **Park, G. W., An, J., Kim, S. W., & Lee, B. H. (2021).** Effects of Sling-Based Thoracic Active Exercise on Pain and Function and Quality of Life in Female Patients with Neck Pain: A Randomized Controlled Trial. *Healthcare (Basel, Switzerland)*, 2021;9(11):1514. <https://doi.org/10.3390/healthcare9111514>
11. **Baik, S. M., Cynn, H. S., Yi, C. H., Lee, J. H., Choi, J. H., & Lee, K. E. (2021).** Effect of side-sling plank exercise on trunk and hip muscle activation in subjects with gluteus medius weakness. *Journal of back and musculoskeletal rehabilitation*, 10.3233/BMR-210061. Advance online publication. <https://doi.org/10.3233/BMR-210061>
12. **Long J, Zhang Y, Liu X, & Jin X.** Effects of sling exercise therapy on post-stroke walking impairment: a systematic review and meta-analysis. *International Journal of Rehabilitation research*. 2021 Oct. doi:10.1097/mrr.0000000000000505.
13. **Dudoniene, V., Kuisma, R., & Juodzbalienė, V. (2021).** Sling suspension therapy is an effective treatment method of juvenile spinal osteochondrosis in adolescent girls. *Journal of back and musculoskeletal rehabilitation*, 10.3233/BMR-210099. Advance online publication. <https://doi.org/10.3233/BMR-210099>
14. **Drummond, C., Lebedeva, V., Kirker, K., & Masaracchio, M.** Sling Exercise in the Management of Chronic Low Back Pain: A Systematic Review and Meta-Analysis. *J Strength Cond Res*. 2021 Sep. doi:10.1519/jsc.0000000000004135. PMID: 34570056.
15. **WANG Chun-hua, FAN Tao-lin, ZHOU Wen-ying, CHEN Dong-dong, XU Long, & YANG Yan-wen.** Study on efficacy of lower limb motor function of sling exercise therapy combined with kinesio taping on dyskinetic cerebral palsy. *Chinese Journal of Child Health Care*, 2021; 29(7): 763-766.

16. **Lin, K-Y., Tsai, Y-J., Hsu P-Y., Tsai, C-S., & Kuo, Y-L.** Effects of Sling Exercise for Neck Pain: A Systematic Review and Meta-Analysis, *Physical Therapy*, 2021; 101(8). <https://doi.org/10.1093/ptj/pzab120>
17. **Huang, D. D., Chen, L. H., Yu, Z., Chen, Q. J., Lai, J. N., Li, H. H., & Liu, G.** Effect of suspension training on neuromuscular function, postural control, and knee kinematics in anterior cruciate ligament reconstruction patients. *World journal of clinical cases*, 2021;9(10):2247–2258. <https://doi.org/10.12998/wjcc.v9.i10.2247>
18. **Filipczyk, P., Filipczyk, K., & Saulicz, E.** Influence of Stabilization Techniques Used in the Treatment of Low Back Pain on the Level of Kinesiophobia. *International journal of environmental research and public health*, 2021;18(12);6393. <https://doi.org/10.3390/ijerph18126393>
19. **Dahl, K. S., & van den Tillaar, R.** The Effect of Eight Weeks of Sling-Based Training with Rotational Core Exercises on Ball Velocity in Female Team Handball Players. *Journal of human kinetics*, 2021;77:261–272. <https://doi.org/10.2478/hukin-2021-0024>
20. **Lakhonina A.I, Aydinova E.A., Brynza M.S, Safronov D.V., Belozorov I.V.** Neurac (Neuromuscular Activation) in cardio-vascular rehabilitation for patients with arterial hypertension. *Fizična rehabilitaciã ta rekreacijno-ozdorovãi tehnologijã*. 2020;5(3):21-25
21. **Bang S-H, Yoon J-G, Park J-M.** Effects of core balance training on Cobb angle, isokinetic torque, and balance in unilateral handed athletes. *Journal of Exercise Rehabilitation*. 2020;16(3):279-285
22. **Park C, Jeong H, Kim B.** Effects of Sling Exercise on Pain and Disability in Patients with Chronic Low Back Pain: Meta-Analysis of Studies in Korea. *Journal of International Academy of Physical Therapy Research*. 2020;11(3):2155-2163
23. **Kim S-Y, Dvir Z, Oh J-S.** The application of the Neurac technique vs. manual therapy in patients during the acute phase of subacromial impingement syndrome: A randomized single-blinded controlled trial. *Journal of Back and Musculoskeletal Rehabilitation*. 2020;33(4):645-653
24. **Liu J, Feng W, Zhou J, Huang F, Long L, Wang Y, Liu PC, Huang X, Yang MZ, Wang K, Sun Z.** Effects of sling exercise therapy on balance, mobility, activities of daily living, quality of life and shoulder pain in stroke patients: a randomized controlled trial. *European Journal of Integrative Medicine*. 2020;35;101077. DOI: 10.1016/j.eujim.2020.101077
25. **Li X, Liu H, Lin K-Y, Miao P, Zhang B-F, Lu S-W, Li L, Wang C-H.** Effects of Different Sling Settings on Electromyographic Activities of Selected Trunk Muscles: A Preliminary Research. *BioMed Research International*. 2020. DOI: 10.1155/2020/2945952
26. **Kim S-Y, Oh J-S.** Scapula muscle exercises using the Neurac technique for a patient after radical dissection surgery: a case report. *Physiotherapy Theory and Practice*, DOI: 10.1080/09593985.2019.1566940. (Online ahead of print)
27. **Cho S-H, Park S-Y.** Immediate effects of isometric trunk stabilization exercises with suspension device on flexion extension ratio and strength in chronic low back pain patients. *Journal of Back and Musculoskeletal Rehabilitation*. 2019;32(3):431-436
28. **Wang S-H, Chen M, Wei X, Gao X-X, Zhao G-D.** Clinical research on lumbar oblique-pulling manipulation in combination with sling exercise therapy for patients with chronic nonspecific low back pain. *Rev. Assoc. Med. Bras*. 2019;65(6):886-892.
29. **Jung KM, Choi JD.** The Effects of Active Shoulder Exercise with a Sling Suspension System on Shoulder Subluxation, Proprioception, and Upper Extremity Function in Patients with Acute Stroke. *Medical science monitor*.2019;25;4849-4855
30. **Gwon AJ, Kim SY, Oh DW.** Effects of integrating Neurac vibration into a side-lying bridge exercise on a sling in patients with chronic low back pain: a randomized controlled study. *Physiotherapy Theory and Practice*, DOI: 10.1080/09593985.2018.1513616 (Epub ahead of print)

31. **Lee JH, Kim TH, Lim KB.** Effects of eccentric control exercise for wrist extensor and shoulder stabilization exercise on the pain and functions of tennis elbow. *Journal of Physical Therapy Science* 2018;30:590-4
32. **Lee SH, Lee SG, Choi BR.** Effect of trunk stabilization exercises on trunk muscle activation using different respiratory conditions. *Journal of Physical Therapy Science* 2018;30:567-9
33. **Ko KJ, Ha GC, Yook YS, Kang SJ.** Effects of 12-week lumbar stabilization exercise and sling exercise on lumbosacral region angle, lumbar muscle strength, and pain scale of patients with chronic low back pain. *Journal of Physical Therapy Science* 2018;30:18-22
34. **Wang JS.** An analysis on muscle tone and stiffness of posterior cervical region during sling and plinth on static prone position. *Journal of Physical Therapy Science* 2017;29:1841-3
35. **Lee JY, Kim SY, Yu JS, Kim DG, Kang EK.** Effects of sling exercise on postural sway in post-stroke patients. *Journal of Physical Therapy Science* 2017;29:1368-71
36. **Ishizuka T, Nishida N, Homma Y, Hirayama T, Ishida Y, Kakizak Fi, Konishi M.** Instantaneous changes in respiratory function induced by passive pelvic suspension in the supine position in relation to increased diaphragm excursion. *Journal of Physical Therapy Science* 2017;29:432-7
37. **Ko S, Kim Y, Lee S.** The Effects of Trunk Stabilization Exercises using a Sling on Motor Development and Balance in Infant with Development Disability. *Healthcare and Nursing – Advanced Science and Technology Letters* 2016;132:161-6
38. **Linek P, Saulicz E, Myśliwiec A, Wójtowicz M, Wolny T.** The Effect of Specific Sling Exercises on the Functional Movement Screen Score in Adolescent Volleyball Players: A Preliminary Study. *Journal of Human Kinetics* 2016;54:83-90
39. **Kim JJ.** An analysis on muscle tone and stiffness during sling exercise on static prone position. *Journal of Physical Therapy Science* 2016;28(12):3440-3
40. **Lee SB, Cho WJ.** The effect of sling exercise on sagittal lumbosacral angle and intervertebral disc area of chronic low back pain patients. *Journal of Exercise Rehabilitation* 2016;12(5):471-5
41. **Turgut E, Pedersen Ø, Duzgun I, Baltaci G.** Three-dimensional scapular kinematics during open and closed kinetic chain movements in asymptomatic and symptomatic subjects. *Journal of Biomechanics* 2016;49:2770-7
42. **Chen L, Chen J, Peng Q, Chen J, Zou Y, Liu G.** Effect of Sling Exercise Training on Balance in Patients with Stroke: A Meta-Analysis. *PLoS ONE* 2016;11(10):e0163351, 13 pages
43. **Roh HS, Cho WJ, Ryu WJ, Park SJ, An SC.** The change of pain and lumbosacral sagittal alignment after sling exercise therapy for patients with chronic low back pain. *Journal of Physical Therapy Science* 2016;28(10):2789-92
44. **Choi K, Bak J, Cho M, Chung Y.** The effects of performing a one-legged bridge with hip abduction and use of a sling on trunk and lower extremity muscle activation in healthy adults. *Journal of Physical Therapy Science* 2016;28(10):2625-8
45. **Kim MK, Cha HG, Shin YJ.** Effects of lumbopelvic sling and abdominal drawing-in exercises on lung capacity in healthy adults. *Journal of Physical Therapy Science* 2016;28(8):2181-3
46. **Park H, Jeong T, Lee J.** Effects of Sling Exercise on Flexibility, Balance Ability, Body Form, and Pain in Patients with Chronic Low Back Pain. *Rehabilitation Nursing* 2016;0:1-9
47. **Sakamoto R, Miura, Y.** The effect of exercise intervention on frail elderly in need of care: half-day program in a senior day-care service facility specializing in functional training. *Journal of Physical Therapy Science* 2016;28(7):1957-63
48. **Lee J, Jeong K, Lee H, Shin J, Choi J, Kang S, Lee BH.** Comparison of three different surface plank exercises on core muscle activity. *Physical Therapy Rehabilitation Science* 2016;5(1):29-33

49. **Nasb M, Li Z.** Sling Suspension Therapy Utilization in Musculoskeletal Rehabilitation. *Open Journal of Therapy and Rehabilitation* 2016;4:99-116
50. **Lee M, Han G.** The effect of peculiar complex core balance training on isokinetic muscle functions of the knee and lumbus. *Journal of Physical Therapy Science* 2016;28(4):1294-7
51. **Park MH, Yu JH, Hong JH, Kim JS, Jung SW, Lee DY.** Effect of core muscle thickness and static or dynamic balance on prone bridge exercise with sling by shoulder joint angle in healthy adults. *Journal of Physical Therapy Science* 2016;28(3):945-50
52. **Oh BH, Kim HH, Kim CY, Nam CW.** Comparison of physical function according to the lumbar movement method of stabilizing a patient with chronic low back pain. *Journal of Physical Therapy Science* 2015;27(12):3655-8
53. **Chang WD, Huang WS, Lai PT.** Muscle Activation of Vastus Medialis Oblique and Vastus Lateralis in Sling-Based Exercises in Patients with Patellofemoral Pain Syndrome: A Cross-Over Study. *Evidence-Based Complementary and Alternative Medicine* 2015, Article ID 740315, 8 pages
54. **Kim HJ, Seong HY.** Effects of complex manual therapy on PTSD, pain, function, and balance of male torture survivors with chronic low back pain. *Journal of Physical Therapy Science* 2015;27(9):2763-6
55. **You YL, Su TK, Liaw LJ, Wu WL, Chu IH, Guo LY.** The effect of six weeks of sling exercise training on trunk muscular strength and endurance for clients with low back pain. *Journal of Physical Therapy Science* 2015;27(8):2591-6
56. **Lükens J, Boström KJ, Puta C, Schulte TL, Wagner H.** Using ultrasound to assess the thickness of the transversus abdominis in a sling exercise. *BMC Musculoskeletal Disorders* 2015;16:203
57. **Yi SJ, Kim JS.** The effects of respiratory muscle strengthening exercise using a sling on the amount of respiration. *Journal of Physical Therapy Science* 2015;27(7):2121-4
58. **Lee D, Park J, Lee S.** Effects of bridge exercise on trunk core muscle activity with respect to sling height and hip joint abduction and adduction. *Journal of Physical Therapy Science* 2015;27(6):1997-9
59. **Yu SH, Park SD.** The effects of a neck musculoskeletal intervention on neck pain levels and depression in post-traumatic stress disorder patients. *Journal of Physical Therapy Science* 2015;27(6):1975-8
60. **Kim SY, Kang MH, Lee DK, Oh JS.** Effects of the Neurac® technique in patients with acute-phase subacromial impingement syndrome. *Journal of Physical Therapy Science* 2015;27(5):1407-9
61. **Park SD, Kim SY.** Clinical feasibility of cervical exercise to improve neck pain, body function, and psychosocial factors in patients with post-traumatic stress disorder: a randomized controlled trial. *Journal of Physical Therapy Science* 2015;27(5):1369-72
62. **Yun S, Kim YL, Lee SM.** The effect of neurac training in patients with chronic neck pain. *Journal of Physical Therapy Science* 2015;27(5):1303-7
63. **Yoon SD, Sung DH, Park GD.** The effect of active core exercise on fitness and foot pressure in Taekwondo club students. *Journal of Physical Therapy Science* 2015;27(2):509-11
64. **Lee S wk, Kim SY.** Effects of hip exercises for chronic low-back pain patients with lumbar instability. *Journal of Physical Therapy Science* 2015;27(2):345-8
65. **Wada Y, Sakuraba K, Kubota A.** Effect of the long-term care prevention project on the motor functions and daily life activities of the elderly. *Journal of Physical Therapy Science* 2015;27(1):199-203
66. **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

67. **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
68. **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
69. **Sung YB, Lee JH, Park YH.** Effects of Thoracic Mobilization and Manipulation on Function and Mental State in Chronic Lower Back Pain. *Journal of Physical Therapy Science* 2014;26(11):1711-4
70. **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
71. **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(9):1363-6
72. **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
73. **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
74. **Bae CH, Jung YW, Lee DW, Cho SH.** The Effect of Sling Exercise on Muscular Strength and Range of Motion in Female Patients who Received Total Knee Replacement. *Journal of the Korea Academia-Industrial cooperation Society* 2014;15(7):4395-403
75. **Maeo S, Chou T, Yamamoto M, Kanehisa H.** Muscular activities during sling- and ground-based push-up exercise. *BMC Research Notes* 2014;7:192
76. **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
77. **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
78. **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
79. **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
80. **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* 2014;28(6):1626-35
81. **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
82. **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
83. **Kim GY, Kim 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

84. **Kim KY, Sim KC, Kim TG, Bae SH, Lee JC, Kim GD.** Effects of Sling Bridge Exercise with Rhythmic Stabilization Technique on Trunk Muscle Endurance and Flexibility in Adolescents with Low Back Pain. *International Journal of Contents* 2013;9(4):72-7
85. **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):1407-9
86. **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
87. **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.
88. **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
89. **Jeong ED, Chae CW, Yun HK, Woo KS, Kim DH, Kim SM.** The Effects of Sling Bridging Exercise to Pain Scale and Trunk Muscle Activity in Low Back Pain Patients. *J Int Acad Phys Ther Res* 2013;4(1):479-544
90. **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
91. **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
92. **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):1099-1101
93. **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
94. **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
95. **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
96. **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
97. **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
98. **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
99. **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(6):1673-9
100. **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

101. **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
102. **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
103. **Ma SY, Je HD, Kim HD.** A Multimodal Treatment Approach Using Spinal Decompression via SpineMED, Flexion-Distraktion 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
104. **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
105. **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
106. **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
107. **Foss P, Orpana A, Foss AM.** "Rehabilitation of people with fibromyalgia – short and long term effects". *Fibromyalgiblad* 2010;2:18-24
108. **Burkert C.** Wie hilft Neurac bei Ruckenschmerzen. *Praxis Physiotherapie* 2010;3:176-82
109. **Burkert C.** Unspezifische lumbale Ruckenschmerzen. *Zeitschrift fur Physiotherapeuten* 2010;62(9):51-6
110. **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
111. **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
112. **Kirkesola G.** Neurac – a new treatment method for chronic musculoskeletal pain. *Fysioterapeuten* 2009;76(12):16-25
113. **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
114. **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
115. **Marovino T.** Neuromuscular Training In Pain Management. *Practical PAIN MANAGEMENT* 2008;8(9):66-9
116. **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
117. **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
118. **Vestergaard S, Puggaard L, Kronborg C.** Træning/genoptræning at ældre – tre projekter i et sundhedsøkonomisk perspektiv. 2007. Syddansk Universitet 2007
119. **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):252-29



120. **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
121. **Seiler S, Skaanes P.T, Kirkesola G.** Effects of Sling Exercise Training on maximal clubhead velocity in junior golfers. *Medicine & Science in Sports & Exercise* 2006;38(5):286
122. **Brage S, Lærum E, Herland K.** The effect and experiences by implementing the sling training concept "S-E-T Corporate" in Norwegian IA companies. 2005. Unpublished
123. **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
124. **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
125. **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)
126. **Kirkesola G. Sling Exercise Therapy – S-E-T.** 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
127. **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
128. **Moe K, Thom E.** Musculoskeletal disorders and physical activity. Results of a long-term study. *Tidsskriftet for Den norske Lægeforening* 1997;29:4258-61
129. **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

**Biały, M., Kublin, K., Brzuszkiewicz-Kuźmicka, G., & Gnat, R. (2022).**

Myofascial and Movement Tests after Anterior Cruciate Ligament Reconstruction.

*Journal of human kinetics*, 83, 67–75. <https://doi.org/10.2478/hukin-2022-0052>

## ABSTRACT

**Background:** Functional evaluation after anterior cruciate ligament reconstruction is one of the key points involved in decision making about the return of patients to full and unrestricted physical activity.

**Objective:** The objective of the present study was to verify whether myofascial chain NEURAC® and Functional Movement Screen (FMS™) tests can be used to detect functional differences between the operated and the non-operated extremity in patients after anterior cruciate ligament reconstruction.

**Methods:** A total of 83 young and physically active recreational athletes (mean age:  $26.9 \pm 9.7$  years) who underwent primary single-bundle anterior cruciate ligament reconstruction using an autogenous semitendinosus-gracilis tendon graft were evaluated between the 3<sup>rd</sup> and the 4<sup>th</sup> month after surgery. Subjects received a similar, standardised rehabilitation programme. Two experienced raters, blinded to the objective of this study, were involved in functional outcome data collection using myofascial NEURAC® and Functional Movement Screen tests.

**Results:** Only two of the NEURAC® tests showed significant differences in the results between the operated and the non-operated extremity: the supine bridging (mean 2.92 vs. 3.51 points,  $p < 0.001$ ) and prone bridging (mean 2.76 vs. 3.67 points,  $p < 0.001$ ) tests. Additionally, the summary score of all NEURAC® tests significantly differed between extremities (mean 12.08 for the operated vs. 13.67 points for the non-operated extremity,  $p < 0.001$ ).

**Conclusion:** Myofascial tests (supine and prone bridging) in comparison with a battery of Functional Movement Screen tests seem to be more effective in detecting functional differences between the operated and the non-operated extremity at the early stage of recovery after anterior cruciate ligament reconstruction.

**Yan, Z. W., Yang, Z., Zhao, F. L., Gao, Y., Wu, Z. K., Wang, J. L., & Zhou, M.**

Effect of sling exercise therapy on surface electromyography and muscle thickness of superficial cervical muscle groups in female patients with chronic neck pain.

*Journal of back and musculoskeletal rehabilitation*, 2022. <https://doi.org/10.3233/BMR-220030>

## **ABSTRACT**

**Background:** The persistence of symptoms in patients with chronic neck pain is considered to be associated with variation in the neck muscle structure and associated neuromuscular control. Sling exercise therapy (SET) has been demonstrated to relieve the symptoms of chronic neck pain, whereas it is controversial whether this benefit is correlated to altered neck muscle structure and associated neuromuscular control in the patients.

**Objective:** To investigate the effect of SET on cervical muscle structure (thickness) and associated neuromuscular control in patients with chronic neck pain.

**Methods:** Twenty-five patients with chronic neck pain were randomly assigned to the SET group (n= 12) or the control group (n= 13). The SET group received the SET intervention for 4 weeks, while the control group maintained normal activities of daily living. At baseline and after 4 weeks of intervention, Visual analogue scale and neck disability index were measured in both groups, and changes in the thickness of the superficial cervical muscles were assessed using musculoskeletal ultrasound. Surface electromyography (EMG) was adapted to assess the neuromuscular control of the neck while the participant was performing the crano-cervical flexion test.

**Results:** At 4 weeks, the SET group had a significant reduction of RMS in both UT and SCM of EMG compared to the control group ( $p < 0.05$ ). Regarding ultrasound, the SET group had significantly lower muscle thickness compared to the control group in both the rest position and the MVIC position ( $p < 0.05$ ). There were no within-group differences in the control group ( $p > 0.05$ ), while the SET group showed significant reductions in both RMS and muscle thickness ( $p < 0.05$ ).

**Conclusion:** 4-week SET was effective in reducing pain and dysfunction in patients with chronic neck pain, which may be related to improved neck muscle thickness and neuromuscular control of the neck.

**Kim, S., Salazar Fajardo, J. C., & Yoon, B. (2023).**

Activation of Anterolateral Abdominal Muscles During Sling Bridge Exercises: Comparison of Different Pelvic Positions.

*Journal of sport rehabilitation*, 1–9. <https://doi.org/10.1123/jsr.2022-0216>

## **ABSTRACT**

**Context:** Inappropriate activation of the anterolateral abdominal muscles affects the stability of the lumbopelvic zone and increases the appearance of pain and lesion in the area. Therefore, ways to improve its effective contraction are crucial in rehabilitation. The aim of this study was to compare the activation of the transverse abdominis (TrA), internal oblique (IO), and external oblique (EO) muscles in 3 different pelvic positions (down pelvis [DP], horizontal pelvis [HP], and up pelvis [UP]) during sling bridge exercise (SBE) to determinate which position is more effective to promote a correct contraction of the anterolateral abdominal muscles.

**Design:** Cross-sectional study.

**Methods:** Fifteen participants performed 3 variations (DP, HP, and UP) of a one-legged exercise called "supine pelvic lift" on a sling device. The thicknesses of the TrA, IO, and EO were recorded at rest and at the 3 positions using ultrasound imaging. Thickness, change ratio, lateral slide of TrA, and preferential and contraction activation ratio of TrA, IO, and EO were analyzed.

**Results:** TrA and IO showed greater activation ( $P = .01$ ) in the UP position than the other pelvic positions. In addition, UP position decreased the activation of the EO ( $P = .01$ ).

**Conclusion:** Based on the results of this study, SBE in the UP position has the potential to improve normal contraction patterns of the musculature and can be used in future intervention of the lumbopelvic zone.

**Mun D.-J., Oh H.-J., Lee S.-H. (2022).**

Effects of Sling Exercise on Pain, Trunk Strength, and Balance in Patients with Chronic Low Back Pain.

*J Kor Phys Ther.* 34(3):110-115. <https://doi.org/10.18857/jkpt.2022.34.3.110>

#### **ABSTRACT**

**Purpose:** The purpose of this study was to examine the effect of sling exercise on pain, trunk strength, and balance in patients with chronic low back pain in their 40s and 50s.

**Methods:** Twenty patients with chronic low back pain were divided into two groups, 10 patients in the exercise group using a sling and 10 patients in the waist stabilization exercise group, applying a random assignment, draw-out method, and sling exercise was applied for 50 minutes a day, 3 times a week, for a total of 5 weeks. For data analysis, a corresponding t-test was performed for within-group changes and an independent t-test was performed for inter-group changes, and the significance level was  $\alpha=0.05$ .

**Results:** After 5 weeks, there were significant differences in all items of within-group changes, and the inter-group changes after 5 weeks demonstrated significant differences in pain, trunk flexion strength, and balance.

**Conclusion:** The results of this study showed that exercise using a sling had positive effects on pain, trunk flexion strength, and balance changes in chronic low back pain patients. It is suggested that sling exercise can be used as an intervention method for pain reduction and functional improvement of patients with chronic low back pain in clinical practice.



**Liu, Q., Zhu, C. & Huang, Q.**

Effects of sling exercise on the core endurance and performance of basketball players.

*Revista Brasileira de Medicina do Esporte, 2022; 29.*

## **ABSTRACT**

### **Introduction**

Strong core stability and strength enable the trunk to transfer the maximum amount of torque to the terminal segments, which is conducive to improving athletic performance. Because sling training is a new core exercise method, its effect on trunk endurance relative to basketball performance has rarely been studied.

### **Objective**

To investigate whether a core exercise program in a specific sports group can improve core and sports-specific performance.

### **Methods**

A total of 40 college students majoring in basketball were randomly assigned to training and control groups. A standardized set of core endurance and basketball-specific performance tests were used to determine and assess the effects of sling training on trunk strength, endurance, and control.

### **Results**

Flexor, extensor, and right and left lateral trunk flexor muscles endurance were significantly greater in the training group than in the control group, and the time to complete the layup obstacle course was shorter than in the control group at the end of the training program,  $p < 0.01$ . No differences between the two groups were found in the penalty shot, the fixed position shot, or the vertical jump and reach at the end of the training program.

### **Conclusions**

Sling exercises can improve the core endurance and strength of basketball players and increase the speed of lay-ups over obstructions.

Li, X., Zhang, H., Lo, W., Ge, L., Miao, P., Liu, H., Li, L., & Wang, C.

Sling Exercise Can Drive Cortical Representation of the Transversus Abdominis and Multifidus Muscles in Patients With Chronic Low Back Pain.

*Frontiers in neurology*, 2022; 13, 904002. <https://doi.org/10.3389/fneur.2022.904002>

## Abstract

**Objective:** The transversus abdominis (TrA) and multifidus (MF) muscles are essential in preventing chronic low back pain (CLBP) recurrence by maintaining segmental stabilization and stiffness. Sling exercise is a high-level core stability training to effectively improve the activities of the TrA and MF muscles. However, the neural mechanism for sling exercise-induced neural plasticity change in the primary motor cortex (M1) remains unclear. This study aimed to investigate the role of sling exercise in the reorganization of the motor cortical representation of the TrA and MF muscles.

**Methods:** Twenty patients with CLBP and 10 healthy individuals were recruited. For map volume, area, the center of gravity (CoG) location (medial-lateral location and anterior-posterior location), and latency, two-way ANOVA was performed to compare the effects of groups (the CLBP-pre, CLBP-post, and healthy groups) and the two muscles (the TrA and MF muscles). The Visual Analog Scale (VAS), the Oswestry Disability Index (ODI), and postural balance stability were assessed at baseline and at the end of 2 weeks of sling exercise. Linear correlations between VAS or ODI and CoG locations were assessed by Pearson's correlation test.

**Results:** 2 weeks of sling exercise induced both the anterior-medial ( $P < 0.001$ ) and anterior-posterior ( $P = 0.025$ ) shifts of the MF muscle representation at the left motor cortex in patients with CLBP. Anterior-medial ( $P = 0.009$ ) shift of the TrA muscle representation at the right motor cortex was observed in patients with CLBP. The motor cortical representation of the two muscles in patients with CLBP after sling exercise (TrA:  $2.88 \pm 0.27$  cm lateral and  $1.53 \pm 0.47$  cm anterior of vertex; MF:  $3.02 \pm 0.48$  cm lateral and  $1.62 \pm 0.40$  cm anterior of vertex) closely resembled that observed in healthy individuals (TrA:  $2.83 \pm 0.48$  cm lateral and  $2.00 \pm 0.43$  cm anterior of vertex; MF:  $2.94 \pm 0.43$  cm lateral and  $1.77 \pm 0.48$  cm anterior of vertex). The VAS and the ODI were reduced following the sling exercise (VAS:  $P < 0.001$ ; ODI:  $P < 0.001$ ). Li et al. Sling Exercise for CLBP Patients

**Conclusion:** This study provides evidence that sling training can drive plasticity changes in the motor system, which corresponds with the reduction in pain and disability levels in patients with CLBP.

**Wang, J., Wang, S., Wu, H., Dong, S., & Zhang, B.**

Muscle Energy Technique plus Neurac Method in Stroke Patients with Hemiplegia Complicated by Diabetes Mellitus and Assessment of Quality of Life.

*Disease markers*, 2022, 6318721. <https://doi.org/10.1155/2022/6318721>

**Objective:** To analyze the role of muscle energy technique (MET) plus Neurac method in stroke patients with hemiplegia complicated by diabetes mellitus and the impact on quality of life.

**Methods:** From January 2021 to December 2021, 100 stroke patients with hemiplegia complicated by diabetes mellitus treated in our institution and assessed for eligibility were recruited and randomly assigned (1 : 3) via the random sampling method to either the conventional rehabilitation group or the experimental group. The patients in the experimental group were randomized (1 : 1 : 1) into either the MET group (receives MET), the Neurac group (receives Neurac), or the joint group (receives MET plus Neurac). The primary endpoint is the clinical efficacy, and the second endpoint is the quality of life.

**Results:** The eligible patients had similar pretreatment Barthel index scores, Visual Analogue Scale (VAS) scores, Berg balance scale (BBS) scores, Tinetti scores, Fugl-Meyer scores, and quality of life (QoL) scores ( $P > 0.05$ ). The treatment herein achieved significant improvements in Barthel index scores, VAS scores ( $2:71 \pm 0:28$ ), BBS scores, Tinetti scores, Fugl-Meyer scores, and QoL scores ( $99:67 \pm 10:62$ ), and MET plus Neurac method obtained the best results versus both the conventional rehabilitation and monotherapy of either MET or Neurac ( $P < 0.05$ ).

**Conclusion:** Neurac method plus MET improves the independent mobility of stroke patients with hemiplegia and diabetes, relieves pain, enhances balance and stability, mitigates limb dysfunction, and boosts patients' quality of life, so it is worthy of clinical application





**Michalíková, M., Bednarčíková, L., Ondrejová, B., Barcalová, M. & Živčák, J.**

Effect of Neurac Therapy on plantar pressures distribution and the center of gravity of the human body.

*Acta Technologica*, 2021;7(4):121-124

### **Abstract**

Nowadays, the pathophysiological posture is a problem for a large part of the population, which leads to a deterioration in the quality of life as a result of functional disorders of the human musculoskeletal system. The aim of the presented article is to point out the effectiveness of movement therapy for the correction of the pelvic position and subsequent adjustment of the body posture, which is evaluated by a change in the distribution of plantar pressures as well as the position of the center of gravity projection.

Observations were made on three subjects who reported pain in different areas of the body as a result of incorrect body posture. Input and control measurements were performed on a baropodometer, and Neurac movement therapy in the Redcord system was applied between the individual measurements. The individual exercises were chosen specifically with regard to affect the specific muscle groups.

After evaluating the measured data, it can be stated that the selected movement therapy has a significant effect on the correction of pathophysiological position, which is also demonstrated by changing the distribution of plantar pressures, adjusting the position of the center of gravity projection and also significantly eliminating painful symptoms and increasing movement comfort.

**Song, E. J., Lee, E. J., & Kwon, H. Y.**

The effects of sling exercise program on balance and body activities in children with spastic cerebral palsy.

*Journal of exercise rehabilitation*, 2021; 17(6), 410–417. <https://doi.org/10.12965/jer.2142608.304>

### **Abstract**

**Purpose:** The purpose of this study was to investigate the static and dynamic balance and body activities after administering a trunk stability exercise program using a sling for children with spastic cerebral palsy of Gross Motor Function Classification System (GMFCS) levels III–IV.

**Subjects and Methods:** This study was conducted based on a quasi-experimental study design. Six of the study participants were assigned to the control group and six were assigned to the experimental group using simple random sampling. Both groups underwent a double-blind clinical trial study in which exercise therapy was performed for 40 min twice a week for 8 weeks. The experimental group underwent the sling exercise program and the control group underwent neuro-developmental treatment.

**Results:** The results showed that static and dynamic balance were significantly different before and after intervention in both the experimental and control groups ( $P < 0.05$ ), and there was also a statistically significant difference between the two groups ( $P < 0.05$ ). Gross motor function and activities of daily life showed significant improvement before and after intervention in the experimental group ( $P < 0.05$ ), but there was no statistically significant difference in the control group ( $P < 0.05$ ). There was a statistically significant difference between the two groups ( $P < 0.05$ ).

**Conclusion:** Therefore, the sling exercise program can be used as an effective treatment for improving balance and physical activity in children with cerebral palsy of GMFCS levels III–IV who have difficulty walking. In addition, such exercise will have a positive impact on the independence of such children and help them to participate in social activities

**Park, G. W., An, J., Kim, S. W., & Lee, B. H.**

Effects of Sling-Based Thoracic Active Exercise on Pain and Function and Quality of Life in Female Patients with Neck Pain: A Randomized Controlled Trial.

*Healthcare (Basel, Switzerland)*, 2021;9(11):1514. <https://doi.org/10.3390/healthcare9111514>

### **Abstract**

**Aim:** This study aimed to investigate the effects of sling-based thoracic active exercise on pain, function, and quality of life in female patients with neck pain.

**Subjects and methods:** A total of 27 female patients with neck pain were divided into the sling-based thoracic active exercise group (n = 14) and the control group (n = 13). The study group performed a sling-based thoracic active exercise with cervical manual therapy for 50 min a day, twice a week for 4 weeks, whereas the control group performed a placebo exercise with cervical manual therapy in the same manner as the study group. Evaluation of the degree of pain before and after treatment was based on the pressure pain threshold and numeric pain rating scale scores. The craniovertebral angle and neck disability index (NDI) were used to evaluate neck function, and quality of life was measured using the Short Form-36.

**Results:** Afterwards, the patients' pressure pain thresholds were significantly increased, and the numeric pain rating scale score was significantly decreased in both groups ( $p < 0.05$ ). In terms of function, the craniovertebral angle was significantly increased in both groups ( $p < 0.05$ ), and neck dysfunction significantly decreased ( $p < 0.05$ ). The quality of life significantly increased in both groups ( $p < 0.05$ ). The pressure pain threshold, craniovertebral angle, neck dysfunction index, and quality of life scores ( $p < 0.05$ ) were significantly different between groups, except the numeric pain scale score.

**Conclusion:** Our results showed that sling-based thoracic active exercise is effective in reducing pain and improving function and quality of life in female patients with neck pain, thus emphasizing the need for thoracic treatment for such patients.

**Baik, S. M., Cynn, H. S., Yi, C. H., Lee, J. H., Choi, J. H., & Lee, K. E. (2021)**

Effect of side-sling plank exercise on trunk and hip muscle activation in subjects with gluteus medius weakness.

*Journal of back and musculoskeletal rehabilitation*, 10.3233/BMR-210061. Advance online publication. <https://doi.org/10.3233/BMR-210061>

### **Abstract**

**Background:** The effectiveness of side-sling plank (SSP) exercises on trunk and hip muscle activation in subjects with gluteus medius (Gmed) weakness is unclear.

**Objective:** To quantify muscle activation of the rectus abdominis (RA), external oblique (EO), erector spinae (ES), lumbar multifidus (LM), Gmed, gluteus maximus (Gmax), and tensor fasciae latae (TFL) during SSP with three different hip rotations compared to side-lying hip abduction (SHA) exercise in subjects with Gmed weakness.

**Methods:** Twenty-two subjects with Gmed weakness were recruited. SHA and three types of SSP exercises were performed: SSP with neutral hip (SSP-N), hip lateral rotation (SSP-L), and hip medial rotation (SSP-M). Surface electromyography was used to measure the activation of the trunk and hip muscles.

**Results:** The trunk and hip muscles activations were generally significantly higher level during three SSP than SHA. SSP-M showed significantly lower EO activation while significantly higher ES and LM activation than SSP-L. Gmed activation was significantly higher during SSP-M than during SSP-L. TFL activation was significantly lower during SSP-M than during SSP-N and SSP-L.

**Conclusions:** SSP could be prescribed for patients who have reduced Gmed strength after injuries. Especially, SSP-M could be applied for patients who have Gmed weakness with dominant TFL.



**Long J, Zhang Y, Liu X, Jin X.**

Effects of sling exercise therapy on post-stroke walking impairment: a systematic review and meta-analysis.

*International Journal of Rehabilitation research.* 2021 Oct. doi:10.1097/mrr.0000000000000505.

### **Abstract**

Walking impairment is a common consequence of stroke, resulting in long-term disability. Trunk muscle strength has been proven to be associated with post-stroke walking performance. As a type of trunk training, sling exercise therapy (SET) has been widely used to improve the trunk function in stroke patients. The purpose of this systematic review was to investigate the efficacy of SET on post-stroke walking impairment.

Seven databases were systematically searched for eligible studies from their inception to 1 August 2021. Review Manager 5.3 software was used for this meta-analysis. The overall quality of included studies was evaluated by the physiotherapy evidence database scale. Twenty-five randomized controlled trials involving 1504 patients were included (23 in China and two in South Korea).

In summary, SET more effectively improved the walking ability of post-stroke patients than conventional physical therapy or trunk training. The pooled analysis demonstrated that SET had positive effects on the 10 m maximum walking speed, integrated electromyography value of rectus femoris, biceps femoris and gastrocnemius, functional ambulation category, timed up and go test, and step length. At least in East Asia, our findings support SET to manage the post-stroke walking impairment.

**Dudoniene, V., Kuisma, R., & Juodzbalienė, V.**

Sling suspension therapy is an effective treatment method of juvenile spinal osteochondrosis in adolescent girls.

*Journal of back and musculoskeletal rehabilitation, 2021*

### **Abstract**

**Background:** Juvenile spinal osteochondrosis (JSO) affects vertebral endplates and may cause intervertebral discs alterations. The condition is typically related to pain, and weakness and shortening of trunk muscles. Sling suspension therapy (SST) has been shown to reduce lumbar pain effectively. It is, however, unclear whether SST is superior to other treatment methods in reducing pain, correcting posture, and activating trunk stabilizers in JSO.

**Objective:** In this study, we intended to compare the effectiveness of two different exercise modalities; Sling Suspension Therapy and Gym Ball Exercise in the treatment of JSO in adolescent girls.

**Methods:** A randomised controlled single centre clinical trial was carried out in an inpatient rehabilitation unit at a sanatorium. Forty adolescent girls (age  $16.3 \pm 0.47$  yrs.), who were diagnosed with JSO (according to ICD-10 Version: 2016 - M 42.0) were randomly assigned into two groups: Group 1 - Sling suspension therapy (SST), Group 2 - Gym ball exercises (GBE). Both groups received interventions for 3 weeks, 15 sessions, and 30 minutes a day for 5 consecutive days a week. Back pain, endurance of trunk muscles and standing posture were evaluated pre- and post-interventions.

**Results:** Both groups demonstrated significant improvement in all measured outcomes. SST was more effective in reducing pain ( $p < 0.05$ ), increasing the endurance of trunk muscles ( $p < 0.05$ ) and improving the standing posture ( $p < 0.05$ ) compared to GBE ( $p < 0.05$ ).

**Conclusions:** Sling suspension therapy is more effective compared with Gym ball exercises in the treatment of juvenile spinal osteochondrosis in adolescent girls in terms of back pain, posture and endurance of trunk muscles.



**Drummond, C., Lebedeva, V., Kirker, K. & Masaracchio, M.**

Sling Exercise in the Management of Chronic Low Back Pain: A Systematic Review and Meta-Analysis.

*J Strength Cond Res.* 2021 Sep. doi:10.1519/jsc.0000000000004135. PMID: 34570056

### **Abstract**

**Purpose:** The purpose of this systematic review is to assess the effectiveness of sling exercise therapy (SET) in individuals with chronic low back pain (LBP).

**Methods:** Eligible studies were randomized clinical trials or prospective cohort studies published in the English language that assessed SET on measures of pain, disability, or muscle attributes in chronic LBP.

**Results:** The search identified 1,204 studies, with 12 studies meeting the inclusion criteria. The average score was 7.3 on the Cochrane Risk of Bias Criteria. Meta-analysis comparing SET with general exercise revealed a nonsignificant effect for pain (mean difference [MD] 0.14; 95% confidence interval [CI]: -0.58, 0.87). Meta-analysis comparing SET with motor control training/lumbar stabilization revealed a significant effect favoring SET for pain (MD -4.13; 95% CI: -7.82 to -0.45) and disability (MD -3.19; 95% CI: -4.63 to -1.76). Meta-analysis comparing SET with no treatment revealed a significant effect favoring SET for pain (MD -1.05; 95% CI: -2.82 to -0.71). Meta-analysis comparing SET plus modalities with modalities revealed a significant effect favoring the SET plus modalities group for pain (MD -1.19; 95% CI: -1.48 to -0.89) and a nonsignificant effect for disability (MD -6.67; 95% CI: -17.25 to 3.92).

**Conclusion:** Sling exercise therapy was more effective than all comparisons for various muscle attributes. The overall level of evidence ranged from very low to moderate. Sling exercise therapy is effective in reducing pain, disability, and improving core muscle activation, strength, thickness, and onset in patients with chronic LBP. Because SET demonstrated comparable outcomes with common active interventions, it provides an opportunity to implement pain-free exercises based on the patient's initial functional level early in the plan of care.



**WANG Chun-hua, FAN Tao-lin, ZHOU Wen-ying, CHEN Dong-dong, XU Long, YANG Yan-wen.**

Study on efficacy of lower limb motor function of sling exercise therapy combined with kinesiio taping on dyskinetic cerebral palsy.

Chinese Journal of Child Health Care, 2021; 29(7): 763-766.

#### **Abstract**

**Objective:** To investigate efficacy of lower limb motor function of sling exercise therapy (SET) combined with kinesiio taping on lower limb motor function of children with dyskinetic cerebral palsy, in order to provide clinical evidence for the treatment of these children.

**Methods:** A total of 59 children with dyskinetic cerebral palsy in Children's Rehabilitation Department of Xiangya Boai Rehabilitation Hospital were enrolled in this study from March 2018 to December 2019, and were randomly divided into 3 groups, including control group ( $n=20$ ), SET group ( $n=20$ ) and study group ( $n=19$ ). The control group was given routine rehabilitation, SET group received sling exercise therapy additionally, and the study group was treated with kinesiio taping based on SET group. The three groups were treated for 4 months. 10m maximum walking speed (10 mMWS), Berg Balance Scale (BBS) and Gross Motor Function Measure (GMFM) were used to evaluate the walking ability, balance and gross motor function of children before treatment and in 4 months after treatment.

**Results:** After 4 months of treatment, the scores of 10 mMWS ( $t=3.249, 4.042, 7.761$ ), GMFM ( $t=5.297, 13.128, 20.982$ ) and BBS ( $t=4.025, 7.289, 6.394$ ) of three groups were all better than those before treatment ( $P<0.01$ ). Additionally, the improvements of 10 mMWS, GMFM and BBS scores in study group were significantly higher than those in control group and SET group ( $F=7.071, 4.787, 4.093, P<0.05$ ).

**Conclusions:** Sling exercise therapy combined with kinesiio taping can strengthen the clinical treatment efficacy of children with dyskinetic cerebral palsy, effectively improve the children's balance function, gross motor function and walking ability.



**Lin, K-Y., Tsai, Y-J., Hsu P-Y., Tsai, C-S. & Kuo, Y-L.**

Effects of Sling Exercise for Neck Pain: A Systematic Review and Meta-Analysis

*Physical Therapy*, 2021; 101(8). <https://doi.org/10.1093/ptj/pzab120>

### **Abstract**

**Objective:** The purpose of this review was to evaluate the effects of sling exercise on pain intensity, disability, and health-related quality of life in adults with neck pain.

**Methods:** The Cochrane Central Register of Controlled Trials, EMBASE, Physiotherapy Evidence Database (PEDro), and 6 other databases were searched from inception to July 2020. The reference lists of relevant articles to identify additional trials were also screened. Randomized controlled trials were included if they investigated the effects of sling suspension therapy in patients with neck pain, including mechanical neck disorders, cervicogenic headache, and neck disorders with radicular findings. Studies were required to be published in English or Chinese. The methodological quality and levels of evidence of studies were assessed using the PEDro scale and the Grading of Recommendations Assessment, Development and Evaluation approach, respectively. The random-effects model was used to perform meta-analyses.

**Results:** Eleven randomized controlled trials were included (n = 595). The mean total PEDro score was 4.64 (SD = 1.21) of 10, which indicated a fair methodological quality. The intervention groups showed significant improvements in pain intensity (SMD = -1.23; 95% CI = -1.88 to -0.58) immediately postintervention compared with the control groups. No significant effects were found for disability, cervical range of motion, and health-related quality of life. However, sensitivity analyses revealed significant short-term improvements in pain intensity, disability, and cervical range of motion and sustained effects on disability at intermediate-term follow-up.

**Conclusion:** Sling exercise appears to be beneficial for improvements in pain intensity (moderate- to low-level evidence) among patients with neck pain. However, no definitive conclusion could be made regarding the effect of sling exercise for neck pain due to methodological limitations and high heterogeneity in the included studies.

**Impact:** This review provides overall moderate- to very low-level evidence for health care professionals who may consider including sling exercise in the intervention program for patients with neck pain.

Huang, D. D., Chen, L. H., Yu, Z., Chen, Q. J., Lai, J. N., Li, H. H., & Liu, G.

Effect of suspension training on neuromuscular function, postural control, and knee kinematics in anterior cruciate ligament reconstruction patients.

*World journal of clinical cases*, 2021;9(10):2247–2258. <https://doi.org/10.12998/wjcc.v9.i10.2247>

### Abstract

**BACKGROUND:** Suspension training (SET) is a method of neuromuscular training that enables the body to carry out active training under unstable support through a suspension therapy system. However, there have been few reports in the literature on the application of SET to anterior cruciate ligament reconstruction (ACLR) patients. It is not clear what aspects of the patient's function are improved after SET.

**AIM:** To investigate the effect of SET on the neuromuscular function, postural control, and knee kinematics of patients after ACLR surgery.

**METHODS:** Forty participants were randomized to an SET group or a control group. The SET group subjects participated in a SET protocol over 6 wk. The control group subjects participated in a traditional training protocol over 6 wk. Isokinetic muscle strength of the quadriceps and hamstrings, static and dynamic posture stability test, and relative translation of the injured knee were assessed before and after training.

**RESULTS:** The relative peak torque of the quadriceps and hamstrings in both groups increased significantly ( $P < 0.001$ ), and the SET group increased by a higher percentage than those in the control group (quadriceps:  $P = 0.004$ ; hamstrings:  $P = 0.011$ ). After training, both groups showed significant improvements in static and dynamic posture stability ( $P < 0.01$ ), and the SET group had a greater change than the control group ( $P < 0.05$ ). No significant improvement on the relative translation of the injured knee was observed after training in either group ( $P > 0.05$ ).

**CONCLUSION:** Our findings show that SET promotes great responses in quadriceps and hamstring muscle strength and balance function in ACLR patients.



**Filipczyk, P., Filipczyk, K., & Saulicz, E.**

Influence of Stabilization Techniques Used in the Treatment of Low Back Pain on the Level of Kinesiophobia.

*International journal of environmental research and public health*, 2021;18(12):6393.

#### **Abstract**

**Aim:** The aim of this study was to try to compare the effectiveness of manual therapy techniques in combination with stabilization techniques: the so-called Australian method and the Neurac method in relation to pain sensations and the level of kinesiophobia.

**Subjects and methods:** A total of 69 people were examined, divided into three groups of 23 people each. The Visual Analogue Scale was used to assess the antalgic effect, and the Kinesiophobia Causes Scale questionnaire was used to assess the level of kinesiophobia. Patients improved over four weeks, during which they were assessed three times. The evaluation of the desired parameters was also performed over a 24-week period to assess long-term performance.

**Results:** Stabilization techniques are an effective extension of manual therapy techniques in patients with low back pain. People in the groups additionally improved in terms of stabilization techniques, which are characterized by a lower level of kinesiophobia. Its lowest level was found in the group additionally improved with the Neurac method. In the long-term study, the level of kinesiophobia in this group was still maintained at a reduced level.

**Conclusion:** The use of stabilization techniques involving patients in action may significantly affect the level of kinesiophobia, and thus have a much wider effect than just pain reduction

**Dahl, K. S., & van den Tillaar, R.**

The Effect of Eight Weeks of Sling-Based Training with Rotational Core Exercises on Ball Velocity in Female Team Handball Players.

*Journal of human kinetics*, 2021;77:261–272. <https://doi.org/10.2478/hukin-2021-0024>

### **Abstract**

**Purpose:** The purpose of this study was to investigate whether sling-based training focused on rotational exercises would improve shooting performance in outfield handball players during the competitive season, and whether changes in performance were related to altered levels of core strength and rotational velocity.

**Subjects and methods:** Twenty-five female outfield handball players (mean age  $19.5 \pm 2.0$  years, height  $1.72 \pm 0.06$  m, body mass  $71.5 \pm 8.6$  kg, training experience  $10.3 \pm 2.4$  years), performed 7 m shots, with and without a run-up, and jump shots. Maximal ball velocity, peak rotational velocity of the trunk with different loads and 1RM in a core strength test were measured before and after an 8-week training intervention. Players were divided into a sling-based and a plyometric/sprint training (control) group that trained three times per week for 8 weeks.

**Results:** The main findings were that sling-based training increased ball velocity by on average 3.2% across three techniques tested, while shooting performance decreased by 3% in the control group. However, both training groups demonstrated increased peak rotational velocity with different loads, but not the calculated 1RM core strength after the training period.

**Conclusion:** It was concluded that sling-based training with rotational core exercises could improve maximal ball velocity in female handball players during a competitive season by around 3%. However, this increased ball velocity may have been caused by increased angular velocity in the core, rather than absolute maximal core strength. It is suggested that sling-based training has impacted timing variables of the different involved segments, or possibly power transfer between segments, which may explain the enhancement in ball velocity.



**Lakhonina A.I., Aydinova E.A., Brynza M.S., Safronov D.V., Belozorov I.V.**

Neurac (Neuromuscular Activation) in cardio-vascular rehabilitation for patients with arterial hypertension.

*Fizična rehabilitaciã ta rekreacijno-ozdorovãi tehnologiji. 2020;5(3):21-25*

**The aim of the study:** Studying influence of Neurac method on control of blood pressure in patients with arterial hypertension.

**Materials and methods:** For the group amount of 15 patients with arterial hypertension stage 1-2 the Neurac method was used like rehabilitation tool for treatment.

**Results:** 65% of patients had positive response for provided treatment. For 30% of patients it was possible to reduce the dose of the medications.

**Conclusions:** Providing of Neurac method as a non-drug treatment tool for patients with arterial hypertension helps to improve life quality of the patients, reduce the dose of antihypertensive drugs in non-invasive way.



**Bang S-H, Yoon J-G, Park J-M.**

Effects of core balance training on Cobb angle, isokinetic torque, and balance in unilateral handed athletes.

*Journal of Exercise Rehabilitation.* 2020;16(3):279-285

**Abstract:**

This study aimed to provide fundamental data of core balance training (CBT) on Cobb angle and isokinetic torque and balance in unilateral exercised athletes.

Forty-eight subjects were divided by control group (CON; n=16), non-CBT exercised group in unilateral handed athletes (NEG, n=16), and CBT exercised group in unilateral handed athletes (EG, n=16), respectively.

Although the group by time interaction in the Cobb angle and in the isokinetic torque were not significantly changed in the EG, the balance of the EG showed significantly improved.

As conclusions, these results informed that the 16-week CBT would provide a positive effect on the balance except for the Cobb angle and the isokinetic torque.

**Park C, Jeong H, Kim B.**

Effects of Sling Exercise on Pain and Disability in Patients with Chronic Low Back Pain: Meta-Analysis of Studies in Korea.

*Journal of International Academy of Physical Therapy Research.* 2020;11(3);2155-2163

**Background:** Various treatments have been proposed for chronic low back pain (CLBP), but recent guidelines and reviews recommend regular physical exercise. However, some other studies have reported opposite results that sling exercise (SE) and other exercises (OE) did not differ in improving CLBP.

**Objectives:** To systematically review and meta-analyze the effects of SE on CLBP in studies published in Korea.

**Design:** A Systemic Review and Meta-analysis.

**Methods:** Randomized controlled trials comparing SE with OE and modality therapy (MT), published up to June 2020, were identified by electronic searches. Primary outcomes were pain and disability. The weighted mean difference (WMD) stand mean difference (SMD) and 95% confidence interval (CI) were calculated using a random-effects model.

**Results:** Based on the results of the meta-analysis, SE was effective for pain in the comparison of SE and MT [short-term: WMD=-1.64, 95% CI (-3.06, - 0.22); long-term: WMD=-0.34, 95% CI (-0.42, - 0.26)]. It was effective for pain in the comparison of SE and OE [short-term: WMD=-1.18, 95% CI (- 2.15, - 0.20); long-term: WMD=-0.66, 95% CI (-0.89, -0.43)]. It was also effective for disability in the comparison of SE and MT [short-term: SMD=-15.82, 95% CI (-23.10, -8.54)]. We found no clinically relevant differences in disability between SE and OE. Heterogeneity was high in the comparison of SE and overall variables.

**Conclusion:** If SE is applied to physical therapy to improve the main symptoms of CLBP patients, it may contribute to their recovery. More high-quality randomized studies on the topic are warranted.



**Kim S-Y, Dvir Z, Oh J-S.**

The application of the Neurac technique vs. manual therapy in patients during the acute phase of subacromial impingement syndrome: A randomized single-blinded controlled trial

*Journal of Back and Musculoskeletal Rehabilitation*, 2020;33(4);645-653

**Background:** Although the effect of exercise in patients during the subacute and/or chronic subacromial impingement syndrome has been reported, only a few studies have examined the effect of pain free exercise in the acute phase of this disorder.

**Objective:** To compare the effect of training using the Neurac technique which combines body segments suspension and vibration vs. manual therapy, on various relevant outcome parameters in patients with acute subacromial impingement syndrome (PASIS).

**Method:** Twenty-six patients underwent a 4 week intervention program. Using random assignment, half of the patients were treated using the Neurac device while the other half was treated using manual therapy. The outcome parameters consisted of shoulder pain, shoulder function, range of motion (ROM) and the isokinetic strength of the external and internal rotators at 60 and 180°/s.

**Results:** Following either modes of interventions, the pain, function, and ROM improved significantly compared to pre-intervention levels in both groups. Time-by-group interaction was observed for the rotational strength which increased significantly and exclusively in the Neurac group.

**Conclusion:** Given its positive effect on shoulder pain, function, ROM and the isokinetic strength of the external and internal rotators, we recommend the application of the Neurac technique in PASIS.

**Keywords:** Manual therapy, Neurac, shoulder impingement syndrome



Liu J, Feng W, Zhou J, Huang F, Long L, Wang Y, Liu PC, Huang X, Yang MZ, Wang K, Sun Z.

Effects of sling exercise therapy on balance, mobility, activities of daily living, quality of life and shoulder pain in stroke patients: a randomized controlled trial

*European Journal of Integrative Medicine*. 2020;35;101077. DOI: 10.1016/j.eujim.2020.101077

**Introduction:** In recent years, researchers have focused their attention on the application of sling exercise therapy in stroke rehabilitation, but results have been inconsistent. The aim of this trial was to explore the effectiveness of sling exercise therapy on balance, mobility, activities of daily living, quality of life and shoulder pain in stroke patients compared with routine physiotherapy.

**Methods:** A total of 50 stroke inpatients at The First Affiliated Hospital of the University of South China, Hengyang, Hunan, China, were randomly allocated into one of the two groups: the sling exercise therapy (SET) group (n = 25) received this therapy using a suspension device, and the control group (n = 25) participated in routine physiotherapy. The interventions in both groups were performed once a day for 30 min, five times per week for four weeks. Measurements were undertaken prior to and after interventions in both groups. The observational indices included balance function (Berg Balance Scale, BBS), motor function of the upper and lower limbs (Fugl-Meyer Assessment, FMA), daily living ability (Barthel Index, BI), quality of life (Short Form 36, SF-36), and shoulder pain (Visual Analogue Scale, VAS).

**Results:** After therapy, both the SET group and the control group had significant improvements in BBS, FMA, BI and VAS. Sling exercise therapy improved balance ability ( $\Delta$ BBS:  $Z = -2.16$ ,  $P = 0.031$ ), upper limb motor function ( $\Delta$ Fugl-Meyer-upper:  $Z = -3.88$ ,  $P = 0.000$ ) and shoulder pain ( $\Delta$ VAS:  $t = 2.64$ ,  $P = 0.012$ ) more effectively than routine training in stroke patients. Positive changes in quality of life were found in both groups, although the difference between the two groups was not statistically significant.

**Conclusions:** The sling exercise therapy has been shown to be a safe and effective method to improve balance, mobility, activities of daily living, quality of life and shoulder pain in stroke patients. It could be an important therapeutic strategy to promote comprehensive functional recovery post-stroke.

**Keywords:** Stroke, Sling, Exercise therapy, Rehabilitation, Physiotherapy, Randomized controlled trial,



**Li X, Liu H, Lin K-Y, Miao P, Zhang B-F, Lu S-W, Li L, Wang C-H.**

Effects of Different Sling Settings on Electromyographic Activities of Selected Trunk Muscles: A Preliminary Research

*BioMed Research International*. 2020. DOI: 10.1155/2020/2945952

**Introduction:** The supine and prone sling exercise may facilitate activation of the local trunk muscles. Does the side-lying sling exercise activate trunk muscles more easily than the supine and prone training with sling settings? Clinical work has shown that the side-lying sling exercise could reduce pain in patients with unilateral low back pain (LBP), but the mechanism behind it is unclear. The fundamental purpose of this preliminary study was to examine the electromyography (EMG) characteristics of trunk muscles during different sling lumbar settings on sixteen healthy adults.

**Methods:** Amplitude and mean power frequency (MPF) of EMG signals were recorded from the transversus abdominis (TA), rectus abdominis (RA), multifidus (MF), erector spinae (ES), gluteus maximus (Gmax), and gluteus medius (Gmed) muscles while the subjects performed the supine lumbar setting (SLS), prone lumbar setting (PLS), left side-lying lumbar setting (LSLS), and right side-lying lumbar setting (RSLS).

**Results:** During SLS and PLS, TA and MF showed significantly higher activity than RA and ES on the same side, respectively. The EMG activities of ES, TA, MF, Gmax, and Gmed had significant differences between the different sides during LSLS and RSLS, and the dominant-side muscles showed higher activity than the other side. There was no significant difference in core trunk muscles between different sling lumbar settings-only that the SLS of the MF/ES ratio was significantly higher than LSLS and RSLS.

**Conclusions:** Sling exercises can be an effective measure to enhance MF and TA EMG activity, and the side-lying position can increase dominant-side Gmax and Gmed activity. Side-lying sling training does not activate more core muscles than the supine and prone training. Supine and prone exercise should be preferred over SLT to stabilize the lumbar region because of its high local/global muscle ratio.

**Kim S-Y, Oh J-S.**

Scapula muscle exercises using the Neurac technique for a patient after radical dissection surgery: a case report

*Physiotherapy Theory and Practice*, DOI: 10.1080/09593985.2019.1566940. (Online ahead of print)

**Background:** After radical neck dissection, spinal accessory nerve damage can result in scapular muscle weakness, which causes shoulder pain, dysfunction, and a limited range of motion (ROM); scapular muscle strengthening exercises are used to reduce these symptoms. This report focuses on the importance of trapezius and serratus anterior strength exercises to reduce symptoms after radical neck dissection.

**Case description:** The patient was a 30-year-old female who had received radical neck dissection 3 years previously. She complained of shoulder pain, dysfunction, and limited ROM during shoulder elevation.

**Outcome:** She was successfully treated by increasing trapezius and serratus anterior strength and improving pain, function, and range of motion by applying the Neurac technique for 12 weeks. Further controlled studies are required to identify the generalizability of these findings.

**Keywords:** Neurac; radical dissection surgery; scapula muscle exercise.

**Cho S-H, Park S-Y.**

Immediate effects of isometric trunk stabilization exercises with suspension device on flexion extension ratio and strength in chronic low back pain patients

*Journal of Back and Musculoskeletal Rehabilitation.* 2019;32(3):431-436

**Background:** Recent clinical research has supported the use of suspension devices in rehabilitation procedures both in practice and in theory. Although a longitudinal study has reported on the use of suspension devices among asymptomatic subjects, it is necessary to investigate the immediate effects of suspension exercises in patients with CLBP.

**Objective:** The present study aims to investigate changes in neuromuscular activation after the prescription of suspension exercises in patients with CLBP. A secondary aim was to determine whether practical flexion and extension strength can be effectively enhanced.

**Methods:** Before and after suspension exercise, flexion extension (FE) ratio and trunk strength of flexion and extension were measured. Patients performed two types of suspension exercises: supine bridge and forward leaning exercises. The paired t-test was used to compare the FE ratio and strength data. Pearson correlation coefficient was performed to study the correlation between measured variables.

**Results:** Compared to the pre-exercise measurements, the flexion-extension ratio and trunk extension strength was significantly increased at the post-exercise measurement ( $p < 0.05$ ). The FE ratio in the right lumbar erector spine muscle was significantly correlated with post-exercise trunk extension strength ( $p < 0.05$ ).

**Conclusions:** For patients with chronic lower back pain, stimulation of the lumbar extensor muscle and of proprioception is effective both for strengthening lumbar extensors and for improving the flexion-extension ratio. Consequently, forward leaning and supine bridge exercises with a suspension device are beneficial for normalising neuromuscular control of the erector spinae muscles.

**Keywords:** Electromyography; extensor strengthening; forward leaning; sling.

**Wang S-H, Chen M, Wei X, Gao X-X, Zhao G-D.**

Clinical research on lumbar oblique-pulling manipulation in combination with sling exercise therapy for patients with chronic nonspecific low back pain

*Rev. Assoc. Med. Bras.* 2019;65(6):886-892.

**Objective:** To investigate clinical curative effects of lumbar oblique-pulling manipulation in combination with sling-exercise-therapy training on chronic nonspecific lower back pain.

**Methods:** A total of 60 patients with chronic nonspecific lower back pain in the Outpatient Department were included in this study. These patients were randomly divided into two groups: the observation group and the control group. The control group adopted a single sling-exercise-therapy training three times a week, while the observation group adopted lumbar oblique-pulling manipulation in combination with manipulation treatment once a week. The course of treatment lasted for four weeks.

**Results:** (1) Before and after treatment, the ODI score was compared within the group. A remarkable statistical significance was observed from the third day ( $P<0.05$ ). At the third month of follow-up, the difference in ODI scores between these two groups was statistically significant ( $P<0.05$ ). (2) Before and after treatment, it was observed that differences in VAS scores from the third day were statistically significant ( $P<0.05$ ). (3) The difference in muscle strength between these two groups had remarkable statistical significance in the third month of follow-up ( $P<0.05$ ).

**Conclusion:** The effective rehabilitation function of lumbar oblique-pulling manipulation in combination with sling-exercise-therapy training in patients with CNLBP is superior to that of sling-exercise-therapy training alone.

**Jung KM, Choi JD.**

The Effects of Active Shoulder Exercise with a Sling Suspension System on Shoulder Subluxation, Proprioception, and Upper Extremity Function in Patients with Acute Stroke

*Medical science monitor.*2019;25;4849-4855

**Background:** The aim of this study was to investigate the effect of active shoulder exercise with a sling suspension system on shoulder subluxation, proprioception, and upper extremity function in patients with acute stroke.

**Material and methods:** Thirty-six patients with acute stroke and shoulder subluxation were randomly assigned into two groups. The study group (n=18) received active shoulder exercise with a sling suspension system, and the control group (n=18) received bilateral arm training for 40 minutes, for five days a week, for four weeks. The outcome measures before and after the intervention included measurement of shoulder subluxation distance, shoulder proprioception, the Fugl-Meyer assessment (FMA) scale, and the manual function test (MFT).

**Results:** Comparison of the study group with the control group showed significant differences in all outcome scores post-intervention ( $p < 0.05$ ). The study group had significant improvement in shoulder subluxation distance, shoulder proprioception, the FMA score, and the MFT compared with the control group. There was a significant difference in shoulder subluxation ( $p = 0.001$ ), shoulder proprioception ( $p = 0.046$ ), the FMA score ( $p = 0.002$ ), and the MFT ( $p = 0.007$ ) between the two groups, which favored the study group.

**Conclusions:** Active shoulder exercise with a sling suspension system may be effective in reducing shoulder subluxation, improving proprioception, and upper extremity function in patients following acute stroke.



**Gwon AJ, Kim SY, Oh DW.**

Effects of integrating Neurac vibration into a side-lying bridge exercise on a sling in patients with chronic low back pain: a randomized controlled study

*Physiotherapy Theory and Practice*, DOI: 10.1080/09593985.2018.1513616 (Epub ahead of print)

**Purpose:** This study examined the effects of integrated Neurac vibration during side-lying bridge exercise using a sling system on pain, strength, and balance in patients with chronic low back pain (LBP).

**Subjects and Methods:** A total of 30 patients were randomly assigned to experimental (EG; n = 15) or control groups (CG; n = 15). Both groups performed side-lying bridge exercise; however, the EG group also received Neurac vibration during exercise. Outcome measures included perceived pain level, asymmetry of weight distribution, asymmetry of hip abductor strength (AHAS), and static balance in one-leg standing. A 2 × 2 repeated-measures analysis of variance was used to determine main effects and interaction for each parameter.

**Results:** Significant interaction effects were found between group and time factors for all parameters. Between-group comparisons revealed significant differences in observed changes for all parameters ( $P < 0.05$ ). In within-group comparisons, EG showed significant changes in all parameters after intervention ( $P < 0.05$ ); however, significant changes were only found for pain and AHAS in the CG ( $P < 0.05$ ). Pain score showed greatest effect size ( $d = 0.77$ ) among all parameters, indicating a moderate effect of intervention.

**Conclusion:** The side-lying bridge exercise on a sling system may alleviate pain and improve strength and balance in patients with chronic LBP, with more favorable effects when Neurac vibration is integrated into the exercise plan.

**KEYWORDS:** Low back pain, side-lying bridge, vibration, sling



**Lee JH, Kim TH, Lim KB.**

Effects of eccentric control exercise for wrist extensor and shoulder stabilization exercise on the pain and functions of tennis elbow

*Journal of Physical Therapy Science 2018;30:590-4*

**Purpose:** This study aimed to conduct experiments to examine the effects of wrist eccentric control exercise or shoulder stabilization exercises after a basic direct treatment of the elbow in the treatment of tennis elbow patients in terms of pain and grip strength.

**Subjects and Methods:** The subjects were divided into two groups: one group conducted wrist eccentric control exercise and was comprised of 5 male and 4 female subjects, and the other group received shoulder stabilization exercise and was comprised of 5 male and 4 female subjects.

**Results:** In the intragroup comparison, both groups showed a significant decrease in pain level and a significant increase in the measurement of the tenderness thresholds of the upper trapezius muscle, lateral epicondyle, and grip strength. In the intergroup comparison, the shoulder stabilization exercise group showed a significantly greater increase in the measurement of the tenderness thresholds of the upper trapezius muscle and grip strength, and the differences were not significant in the pain level and tenderness threshold of the lateral epicondyle.

**Conclusion:** Wrist eccentric control exercise and shoulder stabilization exercises can be useful as intervention methods for relief from pain due to lateral epicondylitis and for the improvement of functions impaired by tennis elbow.

**Key words:** Tennis elbow, Wrist eccentric control exercise, Shoulder stabilization



**Lee SH, Lee SG, Choi BR.**

Effect of trunk stabilization exercises on trunk muscle activation using different respiratory conditions

*Journal of Physical Therapy Science 2018;30:567-9*

**Purpose:** The purpose of this study is to evaluate differences in trunk muscle activity after 4 weeks of trunk stabilization exercises performed under expiration and inspiration conditions.

**Subjects and Methods:** Thirty subjects were assigned randomly to an expiration group (n=15) or an inspiration group (n=15). The outcomes measured were magnitude of muscle activation (rectus abdominis, multifidus, internal oblique and external oblique) in the bridge position and performance on a trunk muscle endurance test. Paired t-tests were used to assess the statistical significance of the effects of the trunk stabilization exercise program within each group.

**Results:** Comparison of the electromyography activity of the trunk muscles revealed a significant increase in internal oblique activation in the inspiration group, and a significant increase in multifidus activation in the expiration group. Assessment of the endurance of the trunk muscles revealed a significant increase in both groups.

**Conclusion:** Our results showed that expiration during trunk stabilization exercises increased the activity of the multifidus muscle, while inspiration enhanced the activity of the internal oblique muscle. Different types of respiration seem to differentially affect trunk muscles during trunk stabilization exercises.

**Key words:** Expiration, Inspiration, Trunk stabilization exercise

**Ko KJ, Ha GC, Yook YS, Kang SJ.**

Effects of 12-week lumbar stabilization exercise and sling exercise on lumbosacral region angle, lumbar muscle strength, and pain scale of patients with chronic low back pain.

*Journal of Physical Therapy Science* 2018;30:18-22

**Purpose:** The purpose of this study is to investigate the effects of lumbar stabilization exercise and sling exercise on lumbosacral region angle, lumbar muscle strength, pain scale of patients with chronic low back pain.

**Subjects and Methods:** The subjects of this study were 29 chronic low back pain patient women who were selected among participants in exercise class at K Region Health Promotion Center in South Korea and were randomly assigned to the lumbar stabilization exercise group (n=10), sling exercise group (n=10), and the control group (n=9). Both lumbar stabilization and sling exercise programs were executed for 60 minutes, three times a week, for 12 weeks. Before and after exercise we measured lumbosacral region angle (lumbar lordosis angle, lumbosacral angle, sacral inclination angle), lumbar muscle strength, and pain scale in all subjects. Two-way analysis of variance was conducted to analyze experimental data. In order to analyze the interaction effect, we conducted paired t-test before and after treatment.

**Results:** Lumbar stabilization exercise group and sling exercises group did not affect lumbar lordosis angle, lumbosacral angle and sacral inclination angle. Whereas the lumbar flexion muscle strength and lumbar extension muscle strength significantly increased in the lumbar stabilization exercise group and sling exercise group. The flexibility increased in the lumbar stabilization exercise group and sling exercise group. The pain scale decreased in the lumbar stabilization exercise group and sling exercise group.

**Conclusion:** Both lumbar stabilization exercise and sling exercises are useful therapeutic approaches to chronic back pain.

**Key words:** Lumbar stabilization exercise, Sling exercise, Chronic back pain

**Wang JS.**

An analysis on muscle tone and stiffness of posterior cervical region during sling and plinth on static prone position.

*Journal of Physical Therapy Science* 2017;29:1841-3

**Purpose:** The purpose of this study was to quantitatively analyze changes in muscle tone and stiffness in the posterior cervical region of individuals in a static prone position in a sling or on a plinth.

**Subjects and Methods:** Twenty-four men in their 20s were divided into a sling group and a plinth group, and their changes in muscle tone and stiffness over time in the upper cervical region, lower cervical region, and upper trapezius muscles during a static prone position were measured.

**Results:** The sling group showed increases in the mean values of muscle tone and stiffness in the upper cervical region immediately after the suspension. In addition, this group exhibited statistically significant declines in the muscle tone and stiffness of the upper cervical region and a statistically significant decline in the muscle tone of the upper trapezius region.

**Conclusion:** The findings of this study suggest that for the treatment of the posterior upper cervical region after sling suspension in a static prone position, the time required to reduce the muscle tone and stiffness of this region should be taken into account.

**Key words:** Muscle tone, Posterior cervical region, Sling



**Lee JY, Kim SY, Yu JS, Kim DG, Kang EK.**

Effects of sling exercise on postural sway in post-stroke patients.

*Journal of Physical Therapy Science 2017;29:1368-71*

**Purpose:** To examine the effects of sling exercise on the balance of post-stroke patients.

**Subjects and Methods:** A total of 18 post-stroke patients (13 men; mean age, 55.3 years) were recruited, and randomly assigned them into sling exercise (n=10) and control exercise (n=8) groups. The Good Balance System was used for measurement of velocity (anteroposterior and mediolateral, mm/s), velocity moment (mm<sup>2</sup>/s) of the movement of the center of pressure, and distance (anteroposterior and mediolateral, mm) between the center of pressure and the center point. The changes in mediolateral velocity, anteroposterior velocity, and velocity moment were compared between two groups in addition to the comparison of distance between the center of pressure and the center point of postural sway.

**Results:** The sling exercise group showed more significant improvements in anteroposterior velocity, mediolateral velocity, velocity moment, anteroposterior distance, and mediolateral distance than the control exercise group.

**Conclusion:** Sling exercise improved post-stroke balance performance and could be used as a therapeutic strategy to improve post-stroke functional recovery.

**Key words:** Sling exercise, Stroke, Balance



**Ishizuka T, Nishida N, Homma Y, Hirayama T, Ishida Y, Kakizak Fi, Konishi M.**

Instantaneous changes in respiratory function induced by passive pelvic suspension in the supine position in relation to increased diaphragm excursion.

*Journal of Physical Therapy Science 2017;29:432-7*

**Purpose:** This study aimed to introduce an approach of pelvic suspension (PS) using sling cords and to obtain evidence for changes in respiratory function of healthy subjects.

**Subjects and Methods:** Subjects were 25 healthy men. In the supine position, with hip and knee joints flexed at 90°, the subjects' pelvises were suspended with sling belts. Diaphragm excursion, respiratory function, and respiratory comfort in these postures were measured using ultrasonography, respirometry, and visual analog scale (VAS), respectively.

**Results:** When the pelvis was passively suspended with sling cords, the diaphragm moved 5 mm cranially and diaphragm excursion showed an instantaneous increase compared with the control. The tidal volume (VT) showed an increase and the respiration rate (RR) showed a decrease. The extent of diaphragm excursion was correlated with changes in VT under the control and PS conditions. Independent measurements of pulmonary function revealed that PS reduced the expiratory reserve volume, being correlated positively and negatively to increases in vital and inspiratory capacities, respectively. Furthermore, VAS values for respiratory ease were greater with PS than with the control.

**Conclusion:** These results suggest that PS effectively changed diaphragm excursion and respiratory function, leading to ease of breathing (i.e., deep and slow respiration).

**Key words:** Pelvic suspension, Diaphragm excursion, Respiration function



**Ko S, Kim Y, Lee S.**

The Effects of Trunk Stabilization Exercises using a Sling on Motor Development and Balance in Infant with Development Disability.

*Healthcare and Nursing – Advanced Science and Technology Letters* 2016;132:161-6

Recently, trunk stabilization exercise using a sling has been investigated in a number of studies. But there has been no cases applied to infants. This study was to confirm the effects of trunk stabilization using a sling exercise on motor development and balance in infant with development disability. Seventeen individuals participated in three testing session: GMFM, AIMS, ECAB. The intervention consisted of twice a week for 40 min each time in six weeks. After the intervention, motor development and balance was significant increase ( $p < .05$ ). Also, when balance increased, motor maturity could be significantly improved. The sling exercise for trunk stabilization will be utilized in an effective way to improve the balance and motor development of the young infants with developmental disability. It may refer to a starting point for further study in the future.

**Keywords:** sling exercise, motor development, balance, development disability



**Linek P, Saulicz E, Myśliwiec A, Wójtowicz M, Wolny T.**

The Effect of Specific Sling Exercises on the Functional Movement Screen Score in Adolescent Volleyball Players: A Preliminary Study.

*Journal of Human Kinetics* 2016;54:83-90

The existing data indicate that the result of the Functional Movement Screen (FMS) test influences the likelihood of subsequent injury in professional athletes. Therefore, exercises increasing test scores of the FMS may be useful at various stages of sports activity. This study evaluated the effects of the NEURAC sling exercises method on the FMS test score in teenage volleyball players. The study was conducted on 15 volleyball players aged 14 years. The FMS test was performed three times interspersed with a two-month interval. Between the first and the second assessment, neither additional treatment nor training was applied, while between the second and the third assessment, the participants performed stabilisation exercises based on the NEURAC method. Training was carried out twice a week, for eight weeks. The analysis showed that between the first and the second measurement, no significant differences occurred. The use of specific sling exercises caused a significant improvement in FMS results ( $p \leq 0.01$ ) between the first and the third, as well as the second and the third measurement. The applied stabilisation exercises based on the NEURAC method positively influenced the FMS test result in male subjects practicing volleyball. Performance of such exercises also resulted in more than 90% of the subjects having a total FMS test score  $\geq 17$ , which may be important in the prevention of injuries. The preliminary results indicate that this type of exercise should be included in a teenage volleyball training routine.

**Key words:** stability exercise; Functional Movement Screen; injury; prevention.

**Kim JJ.**

An analysis on muscle tone and stiffness during sling exercise on static prone position.

*Journal of Physical Therapy Science* 2016;28(12):3440-3

**Purpose:** The purpose of this study was to examine changes in the muscle tone and stiffness of the lumbar region while individuals adopted the static prone position using sling suspension.

**Subjects and Methods:** The subjects were 30 healthy women in their 20s. The muscle tone and stiffness of the upper and lower lumbar regions of the sling suspension group and a control group were measured using myotonometry as they maintained the static prone position.

**Results:** The sling suspension group showed statistically significant declines in the muscle tone and stiffness of the upper lumbar region 5–10 min after adopting the initial prone position. They also showed statistically significant declines in the muscle tone and stiffness of the lower lumbar region immediately after being suspended in the slings and a statistically significant decline in the muscle tone of the lower lumbar region 5–10 min after adopting the initial prone position during which the sling suspension was applied. In contrast, the muscle tone and stiffness of the lumbar region of the control group increased while maintaining the static prone position.

**Conclusion:** The static prone position performed on a treatment table using sling suspension can be an effective intervention for reducing the muscle tone and stiffness of the lumbar region.

**Key words:** Muscle tone, Sling, Static prone position





**Lee SB, Cho WJ.**

The effect of sling exercise on sagittal lumbosacral angle and intervertebral disc area of chronic low back pain patients.

*Journal of Exercise Rehabilitation* 2016;12(5):471-5

The purpose of this study was to observe the change of lumbosacral angle and intervertebral disc (IVD) area. The study was conducted on chronic low back pain (CLBP) female patients for 12 weeks by operating sling exercise and general physical therapy. The 57 CLBP were divided into 2 groups which, sling exercise group (SEG, n=34) and general physical therapy group (PTG, n=23). The experiment was conducted three times a week for 12 weeks. The lumbosacral angle, which means the angle between the L1–L2 lumbar was measured by plain radiography. The IVD area, which means the IVD height and volume was measured by magnetic resonance imaging. The pain was measured by visual analogue scale (VAS). As a result, after 12-week exercise, VAS had decreased in all groups. The angle of L3–4 and L4–5 and the height of IVD had increased in SEG. Also, IVD height and volume has more improved in SEG compare the PTG. Therefore, the sling exercise is proper treatment for CLBP patients' recovery because It improve the lumbosacral angle and IVD area.

**Keywords:** Lumbosacral angle, Intervertebral disc area, Visual analogue scale, Chronic low back pain, Sling exercise

**Turgut E, Pedersen Ø, Duzgun I, Baltaci G.**

Three-dimensional scapular kinematics during open and closed kinetic chain movements in asymptomatic and symptomatic subjects.

*Journal of Biomechanics* 2016;49:2770-7

The combination of open kinetic chain (OKC) and closed kinetic chain (CKC) exercises is commonly recommended in shoulder rehabilitation, aiming at improving strength and sport-specific performance. This study aimed to investigate the three-dimensional (3-D) scapular kinematics and bilateral symmetry of scapular motion during dynamic OKC and CKC movements in asymptomatic and symptomatic shoulders. Fifty subjects with unilateral shoulder pain (symptomatic subjects diagnosed with sub-acromial impingement syndrome, n=20) or without shoulder pain during active shoulder elevation (asymptomatic subjects, n=30) participated in the study. Furthermore, 3-D scapular kinematics were recorded using an electromagnetic tracking device in the sagittal plane of shoulder elevation for both the OKC and CKC conditions performed with slings. Data for scapular kinematics and symmetry angle (SA) were analyzed at 30°, 45°, 60°, 90°, and 120° of humerothoracic elevation. Analysis of variance models and Student's t-test were used to make comparisons between conditions. In general, the scapula was more externally rotated, upwardly rotated and anteriorly tilted for asymptomatic shoulders, and more upwardly rotated for symptomatic shoulders during CKC shoulder elevation. Further, comparisons of SA obtained during OKC and CKC movements revealed that during CKC, scapular motion was more symmetrical for upward-downward rotation and anterior-posterior tilt in asymptomatic shoulders and for anterior-posterior tilt in symptomatic shoulders, especially above 90° humerothoracic elevation. Differences in scapular motion during the CKC condition were in a specific pattern and enhanced symmetry, which would be considered to be a position less likely to produce compression of the rotator cuff tendons for both training in asymptomatic populations and for treatment in early rehabilitation of patients, such as those who have shoulder impingement syndrome.

**Keywords:** Shoulder, Scapula, Closed kinetic chain, Kinematics, Biomechanics

**Chen L, Chen J, Peng Q, Chen J, Zou Y, Liu G.**

Effect of Sling Exercise Training on Balance in Patients with Stroke: A Meta-Analysis.

*PLoS ONE* 2016;11(10):e0163351, 13 pages

### **Objective**

This study aims to evaluate the effect of sling exercise training (SET) on balance in patients with stroke.

### **Methods**

PubMed, Cochrane Library, Ovid LWW, CBM, CNKI, WanFang, and VIP databases were searched for randomized controlled trials of the effect of SET on balance in patients with stroke. The study design and participants were subjected to metrological analysis. Berg balance Scale (BBS), Barthel index score (BI), and Fugl-Meyer Assessment (FMA) were used as independent parameters for evaluating balance function, activities of daily living (ADL) and motor function after stroke respectively, and were subjected to meta-analysis by RevMan5.3 software.

### **Results**

Nine studies with 460 participants were analyzed. Results of meta-analysis showed that the SET treatment combined with conventional rehabilitation was superior to conventional rehabilitation treatments, with increased degrees of BBS (WMD = 3.81, 95% CI [0.15, 7.48],  $P = 0.04$ ), BI (WMD = 12.98, 95% CI [8.39, 17.56],  $P < 0.00001$ ), and FMA (SMD = 0.76, 95% CI [0.41, 1.11],  $P < 0.0001$ ).

### **Conclusion**

Based on limited evidence from 9 trials, the SET treatment combined with conventional rehabilitation was superior to conventional rehabilitation treatments, with increased degrees of BBS, BI and FMA, So the SET treatment can improvement of balance function after stroke, but the interpretation of our findings is required to be made with caution due to limitations in included trials such as small sample sizes and the risk of bias. Therefore, more multi-center and large-sampled randomized controlled trials are needed to confirm its clinical applications.



**Roh HS, Cho WJ, Ryu WJ, Park SJ, An SC.**

The change of pain and lumbosacral sagittal alignment after sling exercise therapy for patients with chronic low back pain.

*Journal of Physical Therapy Science* 2016;28(10):2789-92

**Purpose:** This study was conducted to quantify the effect of sling exercise therapy in the recovery of lumbosacral sagittal alignment (LSA) and in the control of low back pain. [Subjects and Methods] A total of 102 chronic low back pain patients were divided into two groups, a physical therapy group and a sling exercise group. In both groups, programs were conducted thrice a week for twelve weeks. With respect to LSA, pelvic tilt (PT), sacral slope (SS), and pelvic incidence (PI) were measured with plain radiography. Pain was measured on a visual analogue scale (VAS).

**Results:** Differences were found in visual analogue scale, delta score of visual analogue scale, pelvic tilt, delta score of pelvic tilt, and delta score of pelvic incidence between sling exercise therapy and physical therapy groups. VAS, pelvic tilt, and pelvic incidence was positively changed after sling exercise. However, only the visual analogue scale was found to be improved after physical therapy.

**Conclusion:** Sling exercise therapy and physical therapy were effective in reducing pain. However, pelvic tilt and pelvic incidence were positively changed after sling exercise therapy for Lumbosacral Sagittal Alignment, but were unchanged after physical therapy. Therefore, sling exercise therapy is more effective than physical therapy for the recovery of Lumbosacral Sagittal Alignment in patients with chronic low back pain.

**Key words:** Sling exercise, Lumbosacral, Low back pain

**Choi K, Bak J, Cho M, Chung Y.**

The effects of performing a one-legged bridge with hip abduction and use of a sling on trunk and lower extremity muscle activation in healthy adults.

*Journal of Physical Therapy Science* 2016;28(10):2625-8

**Purpose:** This study investigated the changes in the muscle activities of the trunk and lower limbs of healthy adults during a one-legged bridge exercise using a sling, and with the addition of hip abduction.

**Subjects and Methods:** Twenty-seven healthy individuals participated in this study (14 males and 13 females). The participants were instructed to perform the bridge exercises under five different conditions. Trunk and lower limb muscle activation of the erector spinae (ES), external oblique (EO), gluteus maximus (GM), and biceps femoris (BF) was measured using surface electromyography. Data analysis was performed using the mean scores of three trials performed under each condition.

**Results:** There was a significant increase in bilateral EO and contralateral GM with the one-legged bridge compared with the one-legged bridge with sling exercise. Muscle activation of the ipsilateral GM and BF was significantly less during the one-legged bridge exercise compared to the one-legged bridge with sling exercise, and was significantly greater during the one-legged bridge with hip abduction compared to the one-legged bridge exercise. The muscle activation of the contralateral GM and BF was significantly greater with the one-legged bridge with hip abduction compared to the general bridge exercise.

**Conclusion:** With the one-legged bridge with hip abduction, the ipsilateral EO, GM and BF muscle activities were significantly greater than those of the one-legged bridge exercise. The muscle activation of all trunk and contralateral lower extremity muscles increased with the bridge with sling exercises compared with general bridge exercises.

**Key words:** Bridge exercise, Surface electromyography, Lower extremity



**Kim MK, Cha HG, Shin YJ.**

Effects of lumbopelvic sling and abdominal drawing-in exercises on lung capacity in healthy adults.

Journal of Physical Therapy Science 2016;28(8):2181-3

**Purpose:** To examine the effects of lumbopelvic sling and abdominal drawing-in exercises on the lung capacities of healthy subjects

**Subjects and Methods:** Twenty-nine healthy subjects with no orthopedic history of the back were recruited. Subjects were randomly assigned to an experimental group and control group. Subjects were allocated to one of two groups; an experimental group that underwent lumbopelvic sling and abdominal drawing-in exercises and a control group the underwent treadmill and abdominal drawing-in exercises. Lung capacities were evaluated 4 weeks after exercises.

**Results:** The experimental group showed significant increments in the EVC and ERV, IRV, VT vs. pre-intervention results, and the control group showed significant increments in the EVC and IRV. Significant intergroup differences were observed in terms of post-training gains in EVC, IRV and VT.

**Conclusion:** Combined application of lumbopelvic sling and drawing-in exercises were found to have a positive effect on lung capacity.

**Key words:** Abdominal drawing in maneuver, Lung capacity, Sling exercise



**Park H, Jeong T, Lee J.**

Effects of Sling Exercise on Flexibility, Balance Ability, Body Form, and Pain in Patients with Chronic Low Back Pain.

*Rehabilitation Nursing* 2016;0:1-9

**Purpose:** The aim of this study was to investigate the effects of sling exercise on pain, balance, flexibility, and body form in patients with chronic low back pain (LBP).

**Design:** The pretest-posttest control group design.

**Methods:** Thirty participants with chronic lumbar pain were divided into three groups (Sling only, Sling+Swing stick flexible bar, and Sling+Ball cushion), and exercised for 12 weeks.

**Findings:** All types of sling exercise provided significant positive effects on pain scale, body balance, flexibility, and body form. In particular, sling exercise with swing stick flexible bar or ball cushion was more effective on body form, flexibility, and balance than a sling alone.

**Conclusions:** In conclusion, sling exercises over a period of 12 weeks had positive effects on flexibility, balance, pain, and body form in patients with chronic lumbar pain.

**Clinical Relevance:** This study has generated effects of sling exercise, which will assist nursing practitioners in prescribing the beneficial physical rehabilitation for patients with chronic LBP.

**Keywords:** Sling exercise; low back pain; stabilization exercise; swing stick flexible bar; ball cushion



**Sakamoto R, Miura, Y.**

The effect of exercise intervention on frail elderly in need of care: half-day program in a senior day-care service facility specializing in functional training.

*Journal of Physical Therapy Science* 2016;28(7):1957-63

**Purpose:** This study investigated the long-term effect of a half-day exercise intervention program on health-related quality of life, life function, and physical function in frail elderly in need of care. The program was conducted at a senior day-care facility specializing in functional training.

**Subjects and Methods:** Subjects included 41 elderly in need of care who had visited the service facility for at least 1 year. Physical function and life function were evaluated at baseline, 6 months, and 12 months. Quality of life was evaluated with the Short Form-36 at baseline and 12 months.

**Results:** Improvements in balance, walking speed and endurance, complex performance abilities, self-efficacy during the activities, and the level and sphere of activity were observed at 6 months and maintained up to 12 months. Moreover, improvements in agility, activities of daily living, life function, and quality of life were also observed at 12 months. Improvements in muscle strength, walking ability, self-efficacy over an action, and activities of daily living were related to the improvement in quality of life.

**Conclusion:** The use of individualized exercise programs developed by physiotherapists led to improvements in activities of daily living and quality of life among elderly in need of care.

**Key words:** Frail elderly in need of care, Exercise intervention, Health-related QOL



**Lee J, Jeong K, Lee H, Shin J, Choi J, Kang S, Lee BH.**

Comparison of three different surface plank exercises on core muscle activity.

*Physical Therapy Rehabilitation Science* 2016;5(1):29-33

**Objective:** This study compared the muscle activities of the erector spinae (ES), the external oblique (EO), and the rectus abdominis (RA) on three different surfaces. The purpose of this study was to determine which surface induces the highest muscle activity during the plank exercises. The information from this study can be used to recommend plank exercises to athletes and patients with weak core muscles.

**Design:** Cross-sectional study.

**Methods:** The subjects include 20 adult males attending S University in Seoul. Participants completed each plank exercise on three different surfaces. To measure muscle activities, researchers used the values from electromyography. The measurement excluded the initial two and final two seconds and collected information on the RA, EO, and ES in each posture of each subject.

**Results:** The left external oblique showed significant differences between the plank position on stable ground (ST) and the plank position using a suspension device (SL) ( $p < 0.05$ ) and between the plank position on the unstable ground (US) and SL ( $p < 0.05$ ). The right rectus abdominis and left rectus abdominis displayed statistically significant differences between the ST and the US ( $p < 0.05$ ) and between the ST and the SL ( $p < 0.05$ ). The right erector spinae had a statistically significant difference between ST and US ( $p < 0.05$ ).

**Conclusions:** The plank exercise strengthens the core muscles effectively, and muscle activity is related to the posture of the exercise and the location of the muscle. These results suggest that plank exercises improve muscle activities. Additionally, plank exercises can be applied to general medical care.

**Key Words:** Electromyography, Isometric exercise, Posture



**Nasb M, Li Z.**

Sling Suspension Therapy Utilization in Musculoskeletal Rehabilitation.

*Open Journal of Therapy and Rehabilitation* 2016;4:99-116

The development of an effective and inexpensive device to restore and enhance the human musculoskeletal functions is of particular interest. Sling exercise therapy (SET) is one of the most effective developed tools in rehabilitation of musculoskeletal disorders, which has been successfully used in various applications ranging from diagnosis to treatment. To the best of our knowledge, SET has never been comprehended and reviewed previously. Therefore, it was highly required to further understand the role of SET in various therapeutic applications. Inspired by this herein, this study is dedicated to emphasize the advancement in utilization of the SET in both diagnosis and treatment as well as their related challenges. This would be concluded by future perspectives of the SET.

**Keywords:** Rehabilitation, Sling, Muscle Training, SET, Sling Exercise Training, Neurac



**Lee M, Han G.**

The effect of peculiar complex core balance training on isokinetic muscle functions of the knee and lumbus.

*Journal of Physical Therapy Science* 2016;28(4):1294-7

**Purpose:** This study aimed to investigate the effect of peculiar complex core balance training on the isokinetic muscle function of the knee joint and lumbus to provide fundamental data for establishing a training program that focuses on improving the performance and prevention of injury by developing the core and low extremity muscles.

**Subjects and Methods:** The participants in this study included a total of ten high school athletes involved in a throwing event for over five years. The subjects were randomly divided into two groups: The experimental group (N=5) and the control group (N=5). The experimental group underwent peculiar complex core balance training.

**Results:** According to the analysis of covariance, there was a significant effect of peculiar complex core balance training. Therefore, the isokinetic muscle function of the knee joint and lumbus in the experimental group participating in peculiar complex core balance training was significantly increased compared to the control group.

**Conclusion:** It is concluded that peculiar complex core balance training had a positive effect on the isokinetic muscle function of the knee and lumbus in throwing event athletes.

**Key words:** Isokinetic muscle function, Knee, Lumbus



**Park MH, Yu JH, Hong JH, Kim JS, Jung SW, Lee DY.**

Effect of core muscle thickness and static or dynamic balance on prone bridge exercise with sling by shoulder joint angle in healthy adults.

*Journal of Physical Therapy Science* 2016;28(3):945-50

**Purpose:** To date, core muscle activity detected using ultrasonography during prone bridge exercises has not been reported. Here we investigated the effects of core muscle thickness and balance on sling exercise efficacy by shoulder joint angle in healthy individuals.

**Subjects and Methods:** Forty-three healthy university students were enrolled in this study. Ultrasonography thickness of external oblique, internal oblique, and transversus abdominis during sling workouts was investigated. Muscle thickness was measured on ultrasonography imaging before and after the experiment. Dynamic balance was tested using a functional reaching test. Static balance was tested using a Tetrax Interactive Balance System.

**Results:** Different muscle thicknesses were observed during the prone bridge exercise with the shoulder flexed at 60°, 90° or 120°. Shoulder flexion at 60° and 90° in the prone bridge exercise with a sling generated the greatest thickness of most transversus abdominis muscles. Shoulder flexion at 120° in the prone bridge exercise with a sling generated the greatest thickness of most external oblique muscles.

**Conclusion:** The results suggest that the prone bridge exercise with shoulder joint angle is an effective method of increasing global and local muscle strength.

**Key words:** Core muscles, Bridge exercise, Ultrasonography

**Oh BH, Kim HH, Kim CY, Nam CW.**

Comparison of physical function according to the lumbar movement method of stabilizing a patient with chronic low back pain.

*Journal of Physical Therapy Science* 2015;27(12):3655-8

**Purpose:** The purpose of this study was to examine the changes caused by lumbar stabilization exercises in chronic low back pain patients.

**Subjects and Methods:** Swiss ball exercise regimen group and sling exercise regimen group exercised for 30 minutes a day, 5 days a week, for 12 weeks. The control group was to continue performing their usual daily living activities.

**Results:** We obtained significant results in both the Swiss ball and sling exercise groups, but not in the control group. The best effect was obtained in the sling exercise group.

**Conclusion:** The Oswestry Low Back Pain Disability Index and visual pain scale scores of the patients with low back pain decreased in both the Swiss ball exercise group and the sling exercise group, and these patients experienced an increase in waist isometric muscular strength after 12 weeks of exercise compared with those doing no exercise (the control group).

**Key words:** Lumbar stabilizing, Sling exercise, Chronic back pain

**Chang WD, Huang WS, Lai PT.**

Muscle Activation of Vastus Medialis Oblique and Vastus Lateralis in Sling-Based Exercises in Patients with Patellofemoral Pain Syndrome: A Cross-Over Study.

*Evidence-Based Complementary and Alternative Medicine* 2015, Article ID 740315, 8 pages

**Objectives.** To examine what changes are caused in the activity of the vastus medialis oblique (VMO) and vastus lateralis (VL) at the time of sling-based exercises in patients with patellofemoral pain syndrome (PFPS) and compare the muscular activations in patients with PFPS among the sling-based exercises.

**Methods.** This was a cross-over study. Sling-based open and closed kinetic knee extension and hip adduction exercises were designed for PFPS, and electromyography was applied to record maximal voluntary contraction during the exercises. The VMO and VL activations and VMO: VL ratios for the three exercises were analyzed and compared.

**Results.** Thirty male (age =  $21.19 \pm 0.68$  y) and 30 female (age =  $21.12 \pm 0.74$  y) patients with PFPS were recruited. VMO activations during the sling-based open and closed kinetic knee extension exercises were significantly higher ( $P = 0.04$  and  $P = 0.001$ ) than those during hip adduction exercises and VMO: VL ratio for the sling-based closed kinetic knee extension and hip adduction exercises approximated to 1.

**Conclusions.** The sling-based closed kinetic knee extension exercise produced the highest VMO activation. It also had an appropriate VMO: VL ratio similar to sling-based hip adduction exercise and had beneficial effects on PFPS.

**Kim HJ, Seong HY.**

Effects of complex manual therapy on PTSD, pain, function, and balance of male torture survivors with chronic low back pain.

*Journal of Physical Therapy Science* 2015;27(9):2763-6

**Purpose:** This study aimed to identify the impact of physiotherapy using complex manual therapy as a part of an integrated treatment for sequelae in the musculoskeletal system of torture survivors.

**Subjects:** This study reviewed 30 male torture survivors presenting with chronic low back pain. They were randomly selected and divided into two groups: an experimental group and a control group.

**Methods:** For the experimental group, complex manual therapy was performed twice a week for 8 weeks to improve the physical sequelae of patients. Improvement was measured using the PDS-K for Post-traumatic Stress Disorder (PTSD), the Visual Analog Scale (VAS) for pain examination, the Korean Oswestry Disability Index (KODI) for back function assessment, and the Balance System SD as a dynamic balance test. The total period of the intervention for both groups was 8 weeks.

**Results:** For the experimental group, PDS-K, VAS, KODI, and the dynamic balance test all showed significant improvements after the intervention, which they did not for the control group. In the comparison of the groups, PDS-K, VAS, KODI, and the dynamic balance test all showed significant differences.

**Conclusion:** Complex manual therapy for torture survivors with chronic low back pain contributes to functional recovery by reducing back pain. The treatment can be considered to have positive effects on sequelae in the musculoskeletal system of torture survivors as they age.

**Key words:** Chronic low back pain, Complex manual therapy, Torture survivor



**You YL, Su TK, Liaw LJ, Wu WL, Chu IH, Guo LY.**

The effect of six weeks of sling exercise training on trunk muscular strength and endurance for clients with low back pain.

*Journal of Physical Therapy Science* 2015;27(8):2591-6

**Purpose:** The purpose of this study was to investigate the effects of 6 weeks sling exercise training for clients with low back pain on the levels of pain, disability, muscular strength and endurance.

**Subjects and Methods:** Twelve chronic LBP subjects participated in this study. Subjects were randomly divided into a control group and a training group. Subjects in the training group performed sling exercise training for six weeks, and participants in the control group did not perform any exercise.

**Results:** Pain, disability levels and muscular strength significantly improved in the training group, but not in the control group. The left multifidus showed a significant improvement in muscular endurance, measured as the slope of the median frequency after training.

**Conclusion:** Six weeks of sling exercise training was effective at reducing pain intensity, and improving the disability level and trunk muscular strength of subjects with low back pain.

**Key words:** Chronic low back pain, Sling exercise training, Slope of median frequency



**Lükens J, Boström KJ, Puta C, Schulte TL, Wagner H.**

Using ultrasound to assess the thickness of the transversus abdominis in a sling exercise.

*BMC Musculoskeletal Disorders* 2015;16:203

**Background:** Activation of the deep stabilizing trunk muscle transversus abdominis (TrA) is important for trunk stabilization and spine stability. Sling exercises are used for the activation of trunk muscles, therefore we determined the thickness of the TrA in a standardized sling exercise in comparison to rest and abdominal press. Furthermore we propose a standardized measurement method, which can be used to compare relative muscle thickness levels in different exercises.

**Methods:** The main objective of the study was to assess and to compare the thickness of the TrA during different conditions; resting condition, sling exercise condition (non-voluntary contraction), and abdominal press condition (voluntary contraction) using a non-invasive ultrasound-based measurement method. Ultrasound measurement (USM; 8.9 MHz, B-mode) was employed to measure the thickness of the TrA in twenty healthy volunteers (13 m, 7 f), each one measured three times with breaks of 48 h. On each measurement day, the subjects were measured on three different conditions: resting condition (RC), sling condition (SC), and abdominal press condition (APC). The USM images were analyzed using a custom-made MatLab script, to determine the thickness of the TrA.

**Results:** A two-way repeated-measurements ANOVA was performed with a significant effect of the factor condition [ $F(2,38) = 47.82$ ,  $p < 0.0001$ ,  $\eta^2 = 0.72$ ], no significant effect of the factor time [ $F(2,38) = 2.45$ ,  $p = 0.1$ ,  $\eta^2 = 0.11$ ], and no significant interaction effect [ $F(4,76) = 0.315$ ,  $p = 0.867$ ,  $\eta^2 = 0.02$ ]. Statistically corrected post-hoc t-tests revealed significant differences in TrA thickness showing that  $RC < SC$  ( $p < 0.001$ ;  $\eta^2 = 0.19$ ;  $d = 0.96$ ),  $SC < APC$  ( $p < 0.0001$ ;  $\eta^2 = 0.23$ ;  $d = 1.10$ ),  $RC < APC$  ( $p < 0.0001$ ;  $\eta^2 = 0.53$ ;  $d = 2.11$ ). As for the test-retest reliability the intra-class correlation coefficient (ICC) yielded a value of 0.71, 0.54, and 0.29, on the conditions RC, SC, and APC, respectively.

**Conclusions:** We showed that the investigated sling exercise can be used to significantly increase the TrA thickness, and that the TrA thickness was significantly different on the three conditions (RC, SC, APC) using the ultrasound-based method.

**Keywords:** Transversus abdominis, Sling system, Ultrasound method, Measurement method



**Yi SJ, Kim JS.**

The effects of respiratory muscle strengthening exercise using a sling on the amount of respiration.

*Journal of Physical Therapy Science* 2015;27(7):2121-4

**Purpose:** The purpose of this study was to present aerobic exercise that can be performed together with respiratory muscle strength training and examine whether the vital capacity of individuals can be enhanced when respiratory muscle strength training is conducted together with aerobic exercise.

**Subjects and Methods:** The subjects were 10 male students and 8 female students. The sling exercise method was used to conduct three types of training to strengthen the muscles around the shoulder joints. A maximal respiratory quotient measurement device was used to measure the vital capacity of the subjects five times.

**Results:** There was a significant difference in each respiratory training time point compared with before the performance of respiratory training.

**Conclusion:** This study presented respiratory muscle strength training using a sling as a training method for respiratory training.

**Key words:** Sling, Aerobic exercise, Respiratory

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

Effects of bridge exercise on trunk core muscle activity with respect to sling height and hip joint abduction and adduction.

*Journal of Physical Therapy Science* 2015;27(6):1997-9

**Purpose:** This study evaluated the effects of bridge exercise on trunk core muscle activity with respect to sling height and hip joint abduction and adduction.

**Subjects:** Fifteen healthy adult males participated.

**Methods:** In the bridge exercise, the height of the sling was set low or high during hip joint abduction and adduction. Electromyography was used to compare the differences between the muscle activities of the transverse abdominis, rectus abdominis, and erector spinae muscles.

**Results:** The muscle activities of the transverse abdominis, rectus abdominis, and erector spinae were significantly higher in the high sling position. Furthermore, the activities of the transverse abdominis and erector spinae were significantly higher during hip joint adduction than abduction regardless of sling height.

**Conclusion:** A high sling height is the most effective intervention for increasing the muscle activities of the transverse abdominis and erector spinae muscles during hip joint adduction in a bridge exercise.

**Key words:** Bridge exercise, Trunk core muscle, Sling

**Yu SH, Park SD.**

The effects of a neck musculoskeletal intervention on neck pain levels and depression in post-traumatic stress disorder patients.

*Journal of Physical Therapy Science* 2015;27(6):1975-8

**Purpose:** To identify the effects of a neck intervention on neck pain and depression in patients with post-traumatic stress disorder (PTSD).

**Subjects:** Thirty-one patients with neck pain and a diagnosis of PTSD were enrolled.

**Methods:** Neck exercise training was performed with the experimental group and neck self-exercise (using a modification of the McKenzie exercise) was used with the control group. Both groups performed their exercises for 30 minutes at a time, three times per week. To compare the effects of the interventions, the threshold of neck tenderness and depression levels were measured at each period.

**Results:** The pain threshold of both sides of the trapezius showed a significant difference between the two groups at the three measurement periods. In the experimental group, the threshold increased by 19.7% on the left and 18.3% on the right after the intervention compared to before. Depression levels significantly differed in the experimental group between the three measurements.

**Conclusion:** This study has important implications for therapeutic strategies, as it provides strong evidence for a method of improving symptoms of neck pain; furthermore, it is effective for subjects with psychological problems such as PTSD.

**Key words:** Post-traumatic stress disorder, Neck pain, Depression



**Kim SY, Kang MH, Lee DK, Oh JS.**

Effects of the Neurac® technique in patients with acute-phase subacromial impingement syndrome.

*Journal of Physical Therapy Science* 2015;27(5):1407-9

**Purpose:** This study investigated the effects of the Neurac technique on shoulder pain, function, and range of motion in patients with acute-phase subacromial impingement syndrome.

**Subjects:** Thirteen patients (seven females and six males) with acute-phase subacromial impingement syndrome participated in this study.

**Methods:** Shoulder pain, function, and range of motion were assessed before and after the application of the Neurac technique.

**Results:** Pain and function scores were significantly lower after than before the Neurac intervention. Shoulder range of motion was significantly greater after Neurac intervention than before it.

**Conclusion:** The Neurac technique is a useful intervention for patients with acute-phase subacromial impingement syndrome.

**Key words:** Acute-phase subacromial impingement syndrome, Neurac technique, Shoulder pain



**Park SD, Kim SY.**

Clinical feasibility of cervical exercise to improve neck pain, body function, and psychosocial factors in patients with post-traumatic stress disorder: a randomized controlled trial.

*Journal of Physical Therapy Science* 2015;27(5):1369-72

**Purpose:** To investigate the effect of cervical exercise on neck pain, disability, and psychosocial factors in patients with post-traumatic stress disorder.

**Subjects:** Thirty patients with post-traumatic stress disorder, who also complained of neck pain.

**Methods:** The cervical exercise group (n = 15) participated in cervical exercises for 30 min, 3 times/week for 6 weeks, and the control group (n = 16) underwent conventional physical therapy alone, without exercise. The exercises were performed in the following order: cervical relaxation, local muscle stabilization, and global muscle stabilization using a sling system.

**Results:** Compared to the control group, the cervical exercise group demonstrated significant decreases as follows: Visual analogue scale score, 4.2 vs. 1.0; Neck disability index, 3.9 vs. 1.9; and depression on the Symptom checklist-90-revised, 9.4 vs. 4.3 and on the Hopkins symptom checklist-25, 6.3 vs. 2.8. However, anxiety on the Symptom checklist-90-revised (3.1 vs. 1.3) was not significantly different. Effect sizes were as follows: Visual analogue scale score, 1.8; Neck disability index, 0.9; depression, 1.0; and anxiety on Symptom checklist-90-revised and Hopkins symptom checklist-25, 0.6 and 0.8, respectively.

**Conclusion:** Cervical exercise is effective in improving neck pain, disability, and efficacy of psychological treatment for depression in patients with post-traumatic stress disorder.

**Key words:** Post-traumatic stress disorder, Neck pain, Psychosocial factors



**Yun S, Kim YL, Lee SM.**

The effect of neurac training in patients with chronic neck pain.

*Journal of Physical Therapy Science* 2015;27(5):1303-7

**Purpose:** This study aimed to investigate the effects of neurac training on pain, function, balance, fatigability, and quality of life.

**Subjects and Methods:** Subjects with chronic neck pain who were treated in S hospital were included in this study; they were randomly allocated into two groups, i.e., the experimental group (n = 10) and the control group (n = 10). Both groups received traditional physical therapy for 3 sessions for 30 min per week for 4 weeks. The experimental group practiced additional neurac training for 30 min/day, for 3 days per week for 4 weeks. All subjects were evaluated using the visual analogue scale (VAS), the neck disability index (NDI), the biorescue (balance), the questionnaire for fatigue symptoms (fatigue), and the medical outcome 36-item short form health survey (SF-36) pre- and post-intervention.

**Results:** The experimental group effectively improved their pain, function, balance, fatigability, and quality of life.

**Conclusion:** Neurac training is thus considered an effective training program that enhances body functionality by improving pain, function, balance ability, fatigability, and quality of life in patients with chronic neck pain.

**Key words:** Chronic neck pain, Sling-neurac training, Function

**Yoon SD, Sung DH, Park GD.**

The effect of active core exercise on fitness and foot pressure in Taekwondo club students.

*Journal of Physical Therapy Science* 2015;27(2):509-11

**Purpose:** The effects of core training using slings and Togus on the improvement of posture control in Taekwondo club students, that is, balance ability, were investigated. To that end, changes in the Taekwondo players' balance ability resulting from active core training for eight weeks were examined through fitness and foot pressure.

**Subjects:** The present study was conducted with 13 male Taekwondo players of K University in Deagu, South Korea. Once the experiment process was explained, consent was obtained from those who participated voluntarily.

**Methods:** Air cushions (Germany), Jumpers (Germany), and Aero-Steps (Germany) were used as lumbar stabilization exercise tools. As a method of training proprioceptive senses by stimulating somatesthesia in standing postures, the subjects performed balance squats, supine pelvic lifts, and push-up plus exercise using slings while standing on an Aero-Step and performed hip extension parallel squats (Wall Gym Ball), and standing press-ups on a Togu using their own weight. The subjects performed four sets of these isometric exercises while maintaining an exercise time per set at 30 seconds in each session and repeated this session three times per week.

**Results:** Left grip strength significantly increased and number of sit-ups, which indicates muscle endurance, also significantly increased after the eight weeks exercise compared with before the exercise. The values measured during the sit and reach test, which indicate flexibility, also significantly increase after the eight weeks of exercise compared with before the exercise but only in the left foot.

**Conclusion:** The result of present study suggest that active core exercise using Slings and Togus can be applied as a very effective exercise program for enhancing balance, which is an important physical factor for Taekwondo club students.

**Key words:** Sling, Togu, Foot pressure



**Lee S wk, Kim SY.**

Effects of hip exercises for chronic low-back pain patients with lumbar instability.

*Journal of Physical Therapy Science* 2015;27(2):345-8

**Purpose:** The purpose of this study was to compare hip range of motion between a lumbar stability group and a lumbar instability group, and to evaluate the effectiveness of hip exercises for low-back pain patients with lumbar instability.

**Subjects:** Seventy-eight patients with chronic low-back pain were the subjects.

**Methods:** The patients were divided into two groups: a lumbar stability group (n=45) and a lumbar instability group (n=33). They were assessed using the Korean version of the Oswestry Disability Index (KODI) to determine the level of disability of the patients with low-back pain. A 100 mm visual analog scale (VAS) was used to assess low-back pain.

**Results:** The limitation of hip range of motion of the lumbar instability group was significantly greater than that of the lumbar stability group. Comparisons among four groups at three weeks and six weeks after the start of hip exercises revealed that the VAS score of each group had significantly decreased. Comparisons among four groups at three weeks and at six weeks after the start of hip exercises revealed that the KODI score of each group had significantly decreased.

**Conclusion:** These findings suggest that the performance of hip exercises by chronic low-back pain patients with lumbar instability is more effective than conventional therapy at reducing low-back pain and levels of disability.

**Key words:** Chronic low-back pain, Hip exercise, Lumbar instability

**Wada Y, Sakuraba K, Kubota A.**

Effect of the long-term care prevention project on the motor functions and daily life activities of the elderly.

*Journal of Physical Therapy Science* 2015;27(1):199-203

**Purpose:** The purpose of this study was to verify the effects of the long-term care prevention project and develop an effective program.

**Subjects:** A total of 81 elderly people (age,  $79 \pm 5.1$  years; height,  $149.2 \pm 9.2$  cm; weight,  $54.2 \pm 11.4$  kg).

**Methods:** Grip, knee extension muscular strength, 10 m walking speed, and Timed Up and Go time were measured for evaluation of motor functions, and the "Locomo 25", a 25-question risk assessment questionnaire, was used as the judgment criterion for evaluation of daily life activities, with measurements being taken at the beginning of the project and after three months.

**Results:** In the motor functions evaluation, significant differences were observed in 10 m walking speed, Timed Up and Go time, and knee extension strength. In the daily life activities evaluation, scores for pain, rising movement, standing movement, indoor walking, outdoor walking, and fear of falling were significantly reduced. In addition, a significant correlation was also observed between motor functions and daily life activities.

**Conclusion:** The result of this study indicated that the long-term care prevention project is effective in maintaining or improving muscular strength and mitigating pain in the elderly and that it is an effective program for maintaining daily life activities. We were also able to show that it would be effective to develop programs with a low exercise intensity that can be performed on a continuing by the elderly.

**Key words:** Long-term care prevention project, Motor functions, Daily life activities

**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



**Sung YB, Lee JH, Park YH.**

Effects of Thoracic Mobilization and Manipulation on Function and Mental State in Chronic Lower Back Pain.

*Journal of Physical Therapy Science 2014;26(11):1711-4*

**Purpose:** The aim of this study was to evaluate the changes in function and mental state after thoracic mobilization and manipulation in patients with chronic lower back pain (LBP).

**Subjects and Methods:** Thirty-six subjects were randomly divided into mobilization group (group A), manipulation group (group B) and control group (group C). The Oswestry disability index (ODI) was used to measure the functional impairment of patients with LBP. A multiple spinal diagnosis was used to measure the range of motion (ROM) of vertebra segments. The Fear avoidance beliefs questionnaire (FABQ) was used to investigate the mental state of LBP patients.

**Results:** Group A and group B were significantly different from group C in terms of the ODI. Between groups, there was no difference in ROM during trunk flexion. Group A and group B were also significantly different from the control group in extension ROM. The FABQ of group B was significantly different from that of group A.

**Conclusion:** Application of mobilization or manipulation to thoracic lumbar vertebrae has a positive effect on function, mental state, and ROM in patients with lower back pain.

**Key words:** LBP, Mobilization, Manipulation

**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



**Bae CH, Jung YW, Lee DW, Cho SH.**

The Effect of Sling Exercise on Muscular Strength and Range of Motion in Female Patients who Received Total Knee Replacement.

*Journal of the Korea Academia-Industrial cooperation Society* 2014;15(7):4395-403

The purpose of study was to compare the effectiveness of sling exercise on the muscle strength and range of motion in female patients who received a total knee replacement. The participants were allocated randomly into 2 groups: sling exercise group (n=15) and control group (n=15). The subjects were evaluated using the Biodex system for the muscle strength test and a goniometer for the range of motion test. The data was analyzed using a paired t-test and independent t-test to determine the statistical significance. As a result, the sling exercise group before and after intervention showed a statistical significance difference in the flexion angle, quadriceps femoris, and hamstring muscle strength. The control group before and after the intervention revealed a statistically significant increase in the flexion & extension angle, quadriceps femoris, and hamstring muscle strength. Muscle strength test and flexion range of motion test in the sling exercise group showed statistical significance differences compared to the control group ( $p < .05$ ). Therefore, the sling exercise group has a positive influence on the muscle strength and ROM in patients with a total knee replacement.

**Key Words:** Muscular Strength, Range of Motion, Sling Exercise, Total Knee Replacement

**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

**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





**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* 2014;28(6):1626-35

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

**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

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



**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

**Kim KY, Sim KC, Kim TG, Bae SH, Lee JC, Kim GD.**

Effects of Sling Bridge Exercise with Rhythmic Stabilization Technique on Trunk Muscle Endurance and Flexibility in Adolescents with Low Back Pain.

*International Journal of Contents* 2013;9(4):72-7

The purpose of this study was to examine the effects of general sling-bridge exercise (GSE) and sling-bridge exercise with rhythmic stabilization technique (SER) on trunk muscle endurance and flexibility in adolescents with low back pain (LBP). 30 adolescents who had complaints of LBP were randomly assigned to one of the two groups: the GSE group (n=15) and SER group (n=15). Subjects performed each exercise programs for 4 weeks with the aim of improving trunk muscle stability; GSE group trained general bridge exercise with sling, SER group trained rhythmic stabilization bridge exercise with sling. The static and dynamic trunk muscle endurance and flexibility were measured before and at the end of the exercise program. The static and dynamic trunk muscle endurance were significantly improved in both groups ( $p < .05$ ) and the SER group showed significant difference from the GSE group after the exercise ( $p < .05$ ). The trunk muscle flexibility was significantly improved in both groups ( $p < .05$ ) and the SER group were significantly different from GSE group post-exercise ( $p < .05$ ). The results of this study showed that sling bridge exercise with rhythmic stabilization technique may be appropriate for improving trunk muscle stability in adolescents with LBP.

**Key words:** Low Back Pain, Sling-Bridge Exercise, Rhythmic Stabilization Exercise, Muscle Endurance, Flexibility.

**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

**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



**Jeong ED, Chae CW, Yun HK, Woo KS, Kim DH, Kim SM.**

The Effects of Sling Bridging Exercise to Pain Scale and Trunk Muscle Activity in Low Back Pain Patients.

*J Int Acad Phys Ther Res 2013;4(1):479-544*

Most patients with chronic low back pain experience functional disability of trunk muscle, and limitations in physical activity. While there are many types of exercise programs available, in recent years sling exercise has been emerging as the exercise program for spinal stabilization. It has been supported by a great amount of research with positive findings on its effectiveness. This research studies the effects of bridging exercise, conducted on a sling, on pain level and trunk muscle activation in supine, sidelying, and prone positions during a 4 weeks period. 10 healthy people (normal group, n=10) and 28 patients with low back pain participated in this study. 28 patients were divided into two groups; one group participated in exercise with the sling (experimental group, n=14) and the other group exercised without the sling (control group, n=14). They were asked to use the Numerical Rating Scale (NRS) to answer to the level of their pain they felt (no pain: 0 point, severe pain: 10 points). During sling bridging exercises, the muscle activity level in each muscle measured in each position was standardized as three seconds of EMG signals during five seconds MVIC. In conclusion, the experimental group with four weeks of sling bridging exercise experienced a statistically significant reduction in the pain level ( $p < .05$ ) and increase in the muscle activities of erector spinae when in supine position, internal oblique when in sidelying position, and rectus abdominis in prone position ( $p < .05$ ). Regular sling bridging exercise reduces the low back pain and enhances other trunk muscle activation, thereby positively affect spinal stabilization.

**Key words:** Sling Bridging Exercise; Trunk Muscle Activity; Low Back Pain



**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, Staabo, 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  $\pm$  0.3 years, 63.6  $\pm$  6 kg, and 169.6  $\pm$  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  $\pm$  0.5 to 18.8  $\pm$  0.4 m $\cdot$ s<sup>-1</sup> in the SET group after the training period (p < 0.01), but was unchanged in the control group (17.1  $\pm$  0.4 vs. 16.9  $\pm$  0.4 m $\cdot$ 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".

*Fibromyalgibladet* 2010;2:18-24

The article is available only in Norwegian.

**Burkert C.**

Wie hilft Neurac bei Ruckenschmerzen.

*Praxis Physiotherapie* 2010;3:176-82

The article is available only in German.

**Burkert C.**

Unspezifische lumbale Ruckenschmerzen.

*Zeitschrift fur 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·wk<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.