Core Stabilization

Independent Study
Course 29.2.4

Jeevan Pandya, PT, DPT, MHS, OCS, COMT, FAAOMPT
St. Francis Hospital
Indianapolis, IN

Nova Southeastern University
Fort Lauderdale, FL

CONTINUING PHYSICAL THERAPY EDUCATION

ACADEMY OF ORTHOPAEDIC PHYSICAL THERAPY

APTA American Physical Therapy Association

REFERENCES

1. Hubscher M, Zech A, Pfeifer K, Hansel F, Vogt L, Banzer W. Neuromuscular training for sports injury prevention: a systematic review. *Med Sci Sports Exerc*. 2010;42(3):413-421. doi: 10.1249/MSS.0b013e3181b88d37.
2. Kiani A, Hellquist E, Ahlqvist K, Gedeborg R, Michaelsson K, Byberg L. Prevention of soccer-related knee injuries in teenaged girls. *Arch Intern Med*. 2010;170(1):43-49. doi: 10.1001/archinternmed.2009.289.
3. Knapik JJ, Bullock SH, Canada S, et al. Influence of an injury reduction program on injury and fitness outcomes among soldiers. *Inj Prev.* 2004;10(1):37-42.
4. Ekstrom RA, Donatelli RA, Carp KC. Electromyographic analysis of core trunk, hip, and thigh muscles during 9 rehabilitation exercises. *J Orthop Sports Phys Ther*. 2007;37(12):754-762. doi: 10.2519/jospt.2007.2471. Epub 2007 Aug 29.
5. Logan G, McKinney W. *Kinesiology*. New York, NY: McGraw-Hill; 1970.
6. Liemohn WP, Baumgartner TA, Gagnon LH. Measuring core stability. *J Strength Cond Res*. 2005;19(3):583-586.
7. Panjabi MM. Clinical spinal instability and low back pain. *J Electromyogr Kinesiol*. 2003;13(4):371-379.
8. Smith CE, Nyland J, Caudill P, Brosky J, Caborn DN. Dynamic trunk stabilization: a conceptual back injury prevention program for volleyball athletes. *J Orthop Sports Phys Ther*. 2008;38(11):703-720. doi: 10.2519/jospt.2008.2814.
9. Willson JD, Dougherty CP, Ireland ML, Davis IM. Core stability and its relationship to lower extremity function and injury. *J Am Acad Orthop Surg*. 2005;13(5):316-325.
10. Akuthota V, Nadler SF. Core strengthening. *Arch Phys Med Rehabil*. 2004;85(3 suppl 1):S86-S92.
11. Behm DG, Drinkwater EJ, Willardson JM, Cowley PM. The use of instability to train the core musculature. *Appl Physiol Nutr Metab*. 2010;35(1):91-108. doi: 10.1139/H09-127.
12. Colston M. Core stability, part 1: overview of the concept. *Int J Athl Ther Train*. 2012;17(1):8-13.
13. Colston M. Core stability, part 2: the core-extremity link. *Int J Athl Ther Train*. 2012;17(2):10-15.
14. Norris C. *Back Stability*. Champaign, IL: Human Kinetics Inc; 2000.
15. Escamilla RF, Lewis C, Bell D, et al. Core muscle activation during Swiss ball and traditional abdominal exercises. *J Orthop Sports Phys Ther*. 2010;40(5):265-276. doi: 10.2519/jospt.2010.3073.
16. Gibbons SGT, Comerford MJ. Strength versus stability: part 1. Concepts and terms. *Orthop Division Rev*. 2001;2:21-27.
17. Zazulak BT, Hewett TE, Reeves NP, Goldberg B, Cholewicki J. Deficits in neuromuscular control of the trunk predict knee injury risk: a prospective biomechanical-epidemiologic study. *Am J Sports Med*. 2007;35(7):1123-1130.
18. Sahrmann SA. *Diagnosis and Treatment of Movement Impairment Syndromes*. St. Louis, MO: Mosby; 2002.
19. Bogduk, N. Lumbar dorsal ramus syndrome. *Med J Aust* 1980;2(10):537-541.
20. McCall IW, Park WM, O'Brien JP. Induced pain referral from posterior lumbar elements in normal subjects. *Spine (Phila Pa 1976).* 1979;4(5):441-446.
21. Warfield CA. Facet syndrome and the relief of low back pain. *Hosp Pract (Off Ed)*. 1988;23(10A):41-42,47-48.
22. Loebl WY: Measurement of the spinal posture and range of spinal movement. *Ann Phys Med*. 1967;913-110.
23. Ohlen G, Wredmark T, Spangfort E. Spinal sagittal configuration and mobility related to low-back pain in the female gymnast. *Spine (Phila Pa 1976).* 1989;14(8):847-851.
24. Youdas JW, Suman VJ, Garrett TR. Reliability of measurements of lumbar spine sagittal mobility obtained with flexion curve. *J Orthop Sports Phys Ther.* 1995;21(1):13-20.
25. Farfan HF, Sullivan JD. The relation of facet orientation to intervertebral disk failure. *Can J Surg*. 1967;10(2):179-185.
26. Renier JC. Introduction to the biomechanics of the lumbar spine. *Rev Rhum Mal Osteoartic*. 1988;55(5):341-350.
27. Farfan HF. The effects of torsion on the intervertebral joints: the role of torsion in the production of disc degeneration. *J Bone Joint Surg Am.* 1970;52(3):468-497.
28. Wilder DG, Pope MH, Frymoyer JW. The biomechanics of lumbar disc herniation and the effect of overload and instability. *J Spinal Disord.* 1988;1(1):16-32.
29. Cossette JW, Frahan HF, Robertson GH, Wells RV. The instantaneous center of rotation of the third lumbar intervertebral joint. *J Biomech*. 1971;4(2):149-153.
30. Bogduk N, Towmey L. *Clinical Anatomy of the Lumbar Spine.* New York, NY: Churchill Livingstone; 1987.
31. Karacan A, Aydin T, Sahin Z, et al. Facet angles in lumbar disc herniation: their relation to anthropometric features. *Spine*. 2004;29(10):1132-1136.
32. Tencer A, Ahmed A, Burke D. Some static mechanical properties of the lumbar intervertebral joint, intact and injured. *J Biomech Eng*. 1982;104(3):193-201.
33. White A, Panjabi M. *Clinical Biomechanics of the Spine.* 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2018.

34. Nixon J. Intervertebral disc mechanics: a review. *J R Soc Med.* 1986;79(2):100-104.
35. Jensen GM. Biomechanics of the lumbar intervertebral disk: a review. *Phys Ther*. 1980;60(6):765-773.
36. Eyre DR. Biochemistry of the intervertebral disc. *Int Rev Connect Tissue Res*. 1979;8:277-291.
37. Humzah MD, Soames RW. Human intervertebral disc: structure and function. *Anat Rec*. 1988;220(4):337-356.
38. Hendry NG. The hydration of the nucleus pulpous and its relation to intervertebral disc derangement. *J Bone Joint Surg Br*.1958;40-B(1):132-144.
39. Hirsch C. The reaction of intervertebral discs to compression forces. *J Bone Joint Surg Am.* 1955;37-A(6):1188-1191.
40. Keller TS, Holm SH, Hansson TH, Spengler DM. 1990 Volvo Award in experimental studies. The dependence of intervertebral disc mechanical properties on physiological conditions. *Spine (Phila Pa 1976).* 15(8):751-761.
41. Adams MA, Green TP. Tensile properties of the annulus fibrosus. I. The contribution of fibre-matrix interactions to tensile stiffness and strength. *Eur Spine J*. 1993;2(4):203-208.
42. Bogduk N. *Radiological and Clinical Anatomy of the Lumbar Spine*. 5th ed. Philadelphia, PA: Elsevier Churchill Livingstone; 2012.
43. Crisco JJ, Panjabi MM, Yammmotto I, Oxford TR. Stability of the human ligamentous lumbar spine. II: Experiment. *Clin Biomech (Bristol, Avon)*. 1992;7(1):27-32. doi: 10.1016/0268-0033(92)90004-N.
44. Crisco JJ 3rd, Panjabi MM. The intersegmental and multisegmental muscles of the lumbar spine. A biomechanical model comparing lateral stabilizing potential. *Spine (Phila Pa 1976).* 1991;16(7):793-799.
45. Juker D, McGill S, Kropf P, Steffen T. Quantitative intramuscular myoelectric activity of lumbar portions of psoas and the abdominal wall during a wide variety of tasks. *Med Sci Sports Exerc*. 1998;30(2):301-310.
46. Jonsson B. The functions of individual muscles in the lumbar part of the erector spinae muscle. *Electromyography*. 1970;10(1):5-21.
47. Jonsson B, Synnerstad B. Electromyographic studies of the muscles functions in standing: A methodological study. *Acta Morphol Neerl Scand*. 1966;6(4):361-370.
48. Quint U, Wilke HJ, Shirazi-Adl A, Parnianpour M, Löer F, Claes LE. Importance of the intersegmental trunk muscles for the stability of the lumbar spine. A biomechanical study in vitro. *Spine (Phila Pa 1976).* 1998;23(18):1937-1945.
49. Arjmand N, Gagnon D, Plamondon A, Shirazi-Adl A, Larivière C. Comparison of trunk muscle forces and spinal loads estimated by two biomechanical models. *Clin Biomech (Bristol, Avon).* 2009;24(7):533-541
50. Cresswell A, Thortensson A. Changes in intra-articlular pressure, trunk muscle activation and force during isokinetic lifting and lowering. *Eur J Appl Physiol Occup Physiol*. 1994;68(4):315-321.
51. Panjabi MM. The stabilizing system of the spine, part 1: function, dysfunction, adaptation, and enhancement. *J Spinal Disord.* 1992;5(4):383-396.
52. Morris JM, Lucus DB, Bresler B. Role of the trunk in stability of the spine. *J Bone Joint Surg Am.* 1961;43(3):327-351.
53. Akuthota V, Nadler SF. Core strengthening. *Arch Phys Med Rehabil*. 2004;85(3 Suppl):S86-92.
54. Frymoyer JW, Selby DK. Segmental instability. *Spine (Phila Pa 1976)*. 1985;10:280-286.
55. Kaigle A, Wessberg P, Hansson T. Muscular and kinematic behavior of the lumbar spine during flexion-extension. *J Spinal Disord*. 1998;11(2):163-174.
56. Cholewicki J, Panjabi MM, Khachatryan A. Stabilizing function of trunk flexor-extensor muscles around a neutral spine posture. *Spine (Phila Pa 1976)*. 1997;22(19):2207-2212.
57. Hides JA, Stanton WR, McMahon S, Sims K, Richardson CA. Effcect of stabilization training on multifidus muscle cross-sectional area among young elite cricketers with low back pain. *J Orthop Sports Phys Ther*. 2008;38(3):101-108. doi: 10.2519/jospt.2008.2658. Epub 2007 Dec 7.
58. Rohlmann A, Bauer L, Zander T, Bergmann G, Wilke HJ. Determination of trunk muscle forces for flexion and extension by using a validated finite element model of the lumbar spine and measured in vivo data. *J Biomech*. 2006;39(6):981-989.
59. Van Dieen JH, Selen LP, Cholewicki J. Trunk muscle activation in low-back pain patients, an analysis of the literature. *J Electromyogr Kinesiol*. 2003;13(4):333-351.
60. Hodges PW, Ricgardson CA. Inefficient muscular stabilization of the lumbar spine associated with low back pain: A motor control evaluation of transversus abdominis. *Spine (Phila Pa 1976)*. 1996;21(22):2640-2650.
61. Hodges PW, Richardson CA. Contraction of the abdominis associated with movement of lower limb. *Phys Ther*. 1997;77(2):132-142; discussion 142-144.
62. Richardson C, Hodges P, Hides J. *Therapeutic Exercise for Lumbopelvic Stabilization: A Motor Control Approach for the Treatment and Prevention of Low Back Pain.* 2nd ed. London, UK: Churchill Livingstone; 2004.
63. Comerford MJ, Mottram SL. Movement and stability dysfunction—contemporary developments. *Man Ther*. 2001;6(1):15-26.
64. Kirkaldy-Willis WH. Presidential symposium on instability of the lumbar spine. Introduction. *Spine*. 1985;10(3):254.
65. Pope MH, Panjabi M. Biomechanical definitions of spinal instability. *Spine (Phila Pa 1976)*. 1985;10(3):255-256.

66. Boden SD, Wiesel SW. Lumbosacral segmental motion in normal individuals. Have we been measuring instability properly? *Spine (Phila Pa 1976)*. 1990;15(6):571-576.
67. Panjabi MM, Krag MH, White AA 3rd, Southwick WO. Effects of preload on load displacement curves of the lumbar spine. *Orthop Clin North Am.* 1977;8(1):181-192.
68. Panjabi MM. The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. *J Spinal Disord*. 1992;5(4):390-396; discussion 397.
69. Cook C. Coupling behavior of the lumbar: spineA Literature review. *J Man Manipulative Ther*. 2003;11(3):137-145.
70. Troke M, Moore AP, Maillardt FJ, Hough A, Cheek E. A new comprehensive normative database of lumbar spine ranges of motion. *Clin Rehabil*. 2001;15(4):371-379.
71. Dvorak J, Vajda EF, Grob D, Panjabi MM. Normal motion of the lumbar spine as related to age and gender. *Euro Spine J*. 1995;4(1):18-23.
72. Sullivan MS, Dickinson CE, Troup JD. The influence of age and gender on lumbar spine sagittal plane range of motion. A study of 1126 healthy subjects. *Spine (Phila Pa 1976)*. 1994;19(6):682-686.
73. Grice AS. Radiographic, biomechanical, and clinical factors in lumbar lateral flexion: Part 1. *J Manipulative Physiol Ther*. 1979;2(1):26-34.
74. Harrison DE, Harrison DD, Troyanovich SJ. Three dimensional spinal coupling mechanics: Part I. A review of the literature. *J Manipulative Physiol Ther*. 1998;21(2):101-113.
75. Fryette H. *The Principles of Osteopathic Technique*. Carme, CA: Academy of Osteopathy; 1954.
76. Gomez T. Symmetry of lumbar rotation and lateral flexion range of motion and isometric strength in subjects with and without back pain. *J Orthop Sports Phys Ther*. 1994;19(1):42-48.
77. Taylor J, O'Sullivan P. Lumbar segmental instability: Pathology, diagnosis, and conservative management. In: Twomey L, Taylor J, eds. *Physical Therapy of the Low Back*. 3rd ed. Philadelphia, PA: Churchill Livingstone; 2000.
78. Hicks G, Fritz JM, Delitto A, McGill SM. Preliminary development of a clinical prediction rule for determining which patients with low back pain will respond to a stabilization exercise program. *Arch Phys Med Rehabil.* 2005;86(9):1753-1762.
79. Nachemson AL. Instability of the lumbar spine: pathology, treatment, and clinical evaluation. *Neurosurg Clin N Am*. 1991;2(4):785-790.
80. Adams M, Bogduk N, Burton K, Dolan P. *The Biomechanics of Back Pain*. Philadelphia, PA: Elsevier Churchill Livingstone; 2002.
81. O'Sullivan PB. Lumbar segmental 'instability': clinical presentation and specific stabilizing exercise management. *Man Ther*. 2000;5(1):2-12.
82. Hicks GE, Fritz JM, Delito A, Mishock J. Interrater reliability of clinical examination measures for identification of lumbar segmental instability. *Arch Phys Med Rehabil.* 2003;84(12):1858-1864.
83. Leetun DT, Ireland ML, Willson JD, Ballantyne BT, Davis IM. Core stability measures as risk factors for lower extremity injury in athletes. *Med Sci Sports Exerc*. 2004;36(6):926-934.
84. Gabbe BJ, Bennell KL, Wajswelner H, Finch CF. Reliability of common lower extremity musculoskeletal screening tests. *Phys Ther Sport*. 2004;5(2):90-97.
85. Parkhurst TM, Burnett CN. Injury and proprioception in the lower back. *J Orthop Sports Phys Ther*. 1994;19(5):282-295.
86. Kibler WV, Press J, Sciascia A. The role of core stability in athletic function. *Sports Med*. 2006;36(3):189-198.
87. Hodges PW, Pengel LH, Herbert RD, Gandevia SC. Measurement of muscle contraction with ultrasound imaging. *Muscle Nerve*. 2003;27(6):682-692.
88. Teyhen DS, Miltenberger CE, Deiters HM, et al. The use of ultrasound imaging of the abdominal drawing-in maneuver in subjects with low back pain. *J Orthop Sports Phys Ther*. 2005;35(6):346-355.
89. Henry SM, Teyhen DS. Ultrasound imaging as a feedback tool in the rehabilitation of trunk muscle dysfunction for people with low back pain. *J Orthop Sports Phys Ther*. 2007;37(10):627-634.
90. Basmajian JV, De Luca CJ. *Muscles Alive: Their Functions Revealed by Electromyography*. 5th ed. Baltimore, MD: Williams & Wilkins; 1985.
91. Drysdale CL, Earl JE, Hertel J. Surface electromyographic activity of the abdominal muscles during pelvic-tilt and abdominal-hollowing exercises. *J Athl Train*. 2004;39(1):32-36.
92. Youdas JW, Garrett TR, Egan KS, Therneau TM. Lumbar lordosis and pelvic inclination in adults with chronic low back pain. *Phys Ther*. 2000;80(3)61-275.
93. De Paula Lima PO, de Oliveira RR, Costa LO, Laurentino GE. Measurement properties of the pressure biofeedback unit in the evaluation of transversus abdominis muscle activity: a systematic review. *Physiotherapy*. 2011;97(2):100-106.
94. Cairns MC, Harrison K, Wright C. Pressure biofeedback: a useful tool in the quantification of abdominal muscular dysfunction? *Physiotherapy*. 2000;86(3):127-138.
95. Grooms DR, Grindstaff TL, Croy T, Hart JM, Saliba SA. Clinimetric analysis of pressure biofeedback and transversus abdominis function in individuals with stabilization classification low back pain. *J Orthop Sports Phys Ther.* 2013;43(3):184-193.
96. Hodges P, Richardson C, Jull G. Evaluation of the relationship between laboratory and clinical tests of transver-

sus abdominis function. *Physiother Res Int*. 1996;1(1): 30-40.
97. Jull G, Richardson C, Toppenberg R, Comerford M, Bui B. Towards a measurement of active muscle control for lumbar stabilization. *Aust J Physiother*. 1993;39(3):187-193. doi: 10.1016/S0004-9514(14)60481-5. Epub 2014 Mar 27.
98. Van Trijffel E, Anderegg Q, Bossuyt PM, Lucas C. Inter-examiner reliability of passive assessment of intervertebral motion in the cervical and lumbar spine: a systematic review. *Man Ther*. 2005;10(4):256-69.
99. Lurie JD. What diagnostic tests are useful for low back pain? *Best Pract Res Clin Rheumatol.* 2005;19(4):557-575.
100. Alqarni AM, Schneiders AG, Hendrick PA. Clinical tests to diagnose lumbar segmental instability: a systemic review. *J Orthop Sports Phys Ther*. 2011;41(3):130-140. doi: 10.2519/jospt.2011.3457. Epub 2011 Feb 2.
101. Kasai Y, Morishita K, Kawakita E, Kondo T, Uchida A. A new evaluation method for lumbar spinal instability: passive lumbar extension test. *Phys Ther*. 2006;86(12):1661-1667.
102. Hodges PW, Moseley LG. Pain and motor control of the lumbopelvic region: effect and possible mechanisms. *J Electromyogr Kinesiol*. 2003;13(4):361-370.
103. Feuerstein M, Beattie P. Biobehavioral factors affecting pain and disability in low back pain: mechanism and assessment. *Phys Ther.* 1995:75(4):267-280.
104. McDonald D, Moseley L, Hodges PW. The lumbar multifidus: does the evidence support clinical beliefs? *Man Ther*. 2006;11(4):254-263.
105. Hodges P, Moseley G, Gabrielsson A, Gandevia S. Experimental muscle pain changes feedforward postural responses of the trunk muscles. *Exp Brain Res.* 2003;151;262-271.
106. Zedka M, Prochazka A, Knight B, Gillard D, Gauthier M. Voluntary and reflex control of human back muscles during induced pain. *J Physiol*. 1999;520 Pt 2:591-604.
107. Svensson P, Miles TS, Graven-Nielsen T, Arendt-Nielsen L. Modulation of stretch-evoked reflexes in single motor units in human masseter muscle by experimental pain. *Exp Brain Res*. 2000;132(1):65-71.
108. McGill SM, Grenier S, KavcicN, Cholewicki J. Coordination of muscle activity to assure stability of the lumbar spine. *J Electromyogr Kinesiol.* 2003;13(4):353-359.
109. Taimela S, Kankaanpaa M, Luoto S. The effect of lumbar fatigue on the ability to sense a change in lumbar position. A controlled study. *Spine (Phila Pa 1976)*. 1999:24(13):1322-1327.
110. Venna S, Hurri H, Alaranta H. Correlation between neurological leg deficits and reaction time of upper limbs among low-back pain patients. *Scand J Rehabil Med*. 1994;26(2):87-90.
111. Valeriani M, Restuccia D, Di Lazzaro V, et al. Inhibition of the human primary motor area by painful heat stimulation of the skin. *Clin Neurophysiol*. 1999;110(8):1475-1480.
112. Moseley GL, Hodges PW, Gandevia SC. External perturbation to the trunk is associated with differential activity of the deep and superficial fibres of lumbar multifidus. Presented at 4th Interdiscplinary World Congress on Low Back and Pelvic Pain; 2001; Montreal, Canada.
113. Ebenbichler GR, Oddson LI, Kollmitzer J, Erim Z. Sensory-motor control of the lower back: implications for the lower back. *Med Sci Sports Exerc*. 2001;33(11):1889-1898.
114. Janda V. Muscles, central nervous motor regulation and back problems. In: Korr IM, ed. *The Neurobiologic Mechanisms Manipulative Therapy*,. New York, NY: Plenum Press; 1978:27–41.
115. Vlaeyen JW, Linton SJ. Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art. *Pain.* 2000;85(3):317-332.
116. Main CJ, Watson PJ. What harm—pain behavior? Psychological and physical factors in the development of chronicity. *Bull Hosp Jt Dis*. 1996;55(4):210-212.
117. McCarthy C, Arnall F, Strimpakos N, Freemont A, Oldham J. The biopsychosocial classification of non-specific low back pain: a systemic review. *Phys Ther Rev*. 2004;9(1):17-30.
118. van Galen GP, van Huygevoort M. Error, stress and the role of neuromotor noise in space oriented behavior. *Biol Psychol.* 2000;51(2-3):151-171.
119. Vlaeyen JW, Seelen HA, Peters M, et al. Fear of movement/(re)injury and muscular reactivity in chronic low back pain patients: an experimental investigation. *Pain.* 1999;82(3):297-304.
120. Cairns MC, Foster NE, Wright C. Randomized controlled trial of specific spinal stabilization exercises and conventional physiotherapy for recurrent low back pain. *Spine (Phila Pa 1976)*. 2006;31(19):E670-681.
121. Costa LO, Maher CG Latimer J, et al. Motor control exercise for chronic low back pain: a randomized placebo-controlled trial. *Phys Ther*. 2009;89(12):1275-1286.
122. Ferreira ML, Ferreira PH, Latimer J, et al. Comparison of general exercise, motor control exercise and spinal manipulative therapy for chronic low back pain: A randomized trial. *Pain*. 2007;131(1-2):31-37.
123. Koumantakis GA, Watson PJ, Odham JA. Trunk muscle stabilization training plus general exercise versus general exercise only: randomized controlled trial of patients with recurrent low back pain. *Phys Ther*. 2005;85(3):209-225.
124. Smith BE, Littlewood C, May S. An update of stabilization exercises for low back pain: a systemic review with meta-analysis. BMC *Musculoskelet Disord.* 2014;15:416.

125. Wong AY, Parent EC, Funabashi M, Kawchuk GN. Do changes in transversus abdominis and lumbar multifidus during conservative treatment explain changes in clinical outcomes related to nonspecific low back pain? A systematic review. *J Pain*. 2014;15(4):377.e1-35.
126. Lederman E. The myth of core stability. *J Bodyw Mov Ther*. 2010;14(1):84-98.
127. Geisser ME, Ranavaya M, Haig AJ, et al. A meta-analytic review of surface electromyography among persons with low back pain and normal, healthy controls. *J Pain*. 2005;6(11):711-726.
128. Gubler D, Mannion AF, Schenk P, et al. Ultrasound tissue Doppler imaging reveals no delay in abdominal muscle feed-forward activity during rapid arm movements in patients with chronic low back pain. *Spine (Phila Pa 1976)*. 2010;35(16):1506-1513.
129. Wang XQ, Zheng JJ, Yu ZW, et al. A meta-analysis of core stability exercise versus general exercise for chronic low back pain. *PloS One*. 2012;7(12):e52082.