# THE LUMBOPELVIC COMPLEX: ADVANCES IN EVALUATION AND TREATMENT

## Adolescent Spine

Independent Study Course 28.3.5

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CONTINUING PHYSICAL THERAPY EDUCATION

ACADEMY OF ORTHOPAEDIC PHYSICAL THERAPY

APTA American Physical Therapy Association

## REFERENCES


1. Jones G, Macfarlane G. Epidemiology of low back pain in children and adolescents. *Arch Dis Child.* 2005;90(3):312-316.
2. Smith DR, Leggat PA. Back pain in the young: A review of studies conducted among school children and university students. *Curr Pediatr Rev*. 2007;3(1):69-77.
3. Mohseni-Bandpei MA, Bagheri-Nesami M, Shayesteh-Azar M. Nonspecific low back pain in 5000 Iranian school-age children. *J Pediatr Orthop.* 2007;27(2):126-129.
4. Jackson C, McLaughlin K, Teti B. Back pain in children: a holistic approach to diagnosis and management. *J Pediatr Health Care*. 2011;25(5):284-293. doi: 10.1016/j.pedhc.2010.03.003. Epub 2010 May 8.
5. Houghton K. Review for the generalist: evaluation of low back pain in children and adolescents. *Pediatr Rheumatol Online J.* 2010;8:28. doi: 10.1186/1546-0096-8-28.
6. Noll M, Silveria EA, Avelar IS. Evaluation of factors associated with severe and frequent back pain in high school athletes. *PLoS One*. 2017;12(2):e0171978. doi: 10.1371/journal.pone.0171978. eCollection 2017.
7. Muller J, Muller S, Stoll J, Frohlich K, Otto C, Mayer F. Back pain prevalence in adolescent athletes. *Scand J Med Sci Sports*. 2017;27(4):448-454. doi: 10.1111/sms.12664. Epub 2016 Feb 19.
8. Hormer S, Mackintosh S. Injuries in young female elite gymnasts. *Physiotherapy.* 1992;78(11):804-808.
9. Sward L, Hellstrom M, Jacobsson B, Nyman R, Peterson L. Disc degeneration and associated abnormalities of the spine in elite gymnasts. A magnetic resonance imaging study. *Spine (Phila Pa 1976).* 1991;16(4):437-443.
10. Goldstein JD, Berger PE, Windler GE, Jackson DW. Spine injuries in gymnasts and swimmers. An epidemiologic investigation. *Am J Sports Med.* 1991;19(5):463-468.
11. Auerbach J, Ahn J, Zgonis M, Reddy SC, Ecker ML, Flynn JM. Streamlining the evaluation of low back pain in children. *Clin Orthop Related Res.* 2008;466(8):1971-1977. doi: 10.1007/s11999-008-0296-2. Epub 2008 Jun 16.
12. Bhatia NN, Chow G, Timon SJ, Watts HG. Diagnostic modalities for the evaluation of pediatric back pain: A prospective study. *J Pediatr Orthop*. 2008;28(2):230-233. doi: 10.1097/BPO.0b013e3181651bc8.
13. Feldman DS, Straight JJ, Badra MI, Mohaideen A, Madan SS. Evaluation of an algorithmic approach to pediatric back pain. *J Pediatr Orthop.* 2006;26(3):353-357.
14. Miller R, Beck NA, Sampson NR, Zhu X, Flynn JM, Drummond D. Imaging modalities for low back pain in children: a review of spondyloysis and undiagnosed mechanical back pain. *J Pediatr Orthop.* 2013;33(3):282-288. doi: 10.1097/BPO.0b013e318287fffb.
15. Rodriguez D, Poussaint T. Imaging of back pain in children. *AJNR Am J Neuroradiol*. 2010;31(5):787-802. doi: 10.3174/ajnr.A1832. Epub 2009 Nov 19.
16. Delitto A, Erhard RE, Bowling RW. A Treatment-based classification approach to low back syndrome: identifying and staging patients for conservative treatment. *Phys Ther.* 1995;75(6):470-485; discussion 485-489.
17. Micheli L, Wood R. Back pain in young athletes: significant differences from adults in causes and patterns. *Arch Pediatr Adolesc Med*. 1995;149(1):15-18.
18. Rossi F. Spondylosis, spondylolisthesis and sport. *J Sports Med Phys Fitness.* 1978;18(4):317-340.
19. Fredrickson B, Baker D, McHolick WJ, Yuan HA, Lubicky JP. The natural history of spondylolysis and spondylolisthesis. *J Bone Joint Surg Am*. 1984;66(5):699-707.
20. d'Hemecourt P, Zurakowski D, d'Hemecourt C, et al. Validation of a new instrument for evaluating low back pain in the young athlete. *Clin J Sport Med*. 2012;22(3):244-248. doi: 10.1097/JSM.0b013e318249a3ce.
21. Childs JD, Piva SR, Fritz JM. Responsiveness of the numeric pain rating scale in patients with low back pain. *Spine (Phila Pa 1976)*. 2005;30(11):1331-1334.
22. Hagg O, Fritzell P, Nordwall A, Swedish Lumbar Spine Study Group. The clinical importance of changes in outcome scores after treatment for chronic low back pain. *Eur Spine J*. 2003;12(1):12-20.
23. Baeyer CL. Numerical rating scale for self-report of pain intensity in children and adolescents: Recent progress and further questions. *Eur J Pain*. 2009;13(10):1005-1007. doi:10.1016/j.ejpain.2009.08.006. Epub 2009 Sep 17.
24. Miró J, Castarlenas E, Huguet A. Evidence for the use of a numerical rating scale to assess the intensity of pediatric pain. *Eur J Pain.* 2009;13(10):1089-1095. doi:10.1016/j.ejpain.2009.07.002. Epub 2009 Sep 1.
25. Kordi R, Rostami M. Low back pain in children and adolescents: an algorithmic clinical approach. *Iran J Pediatr*. 2011;21(3):259-270.
26. Garra G, Singer AJ, Taira BR, et al. Validation of the Wong-Baker FACES pain rating scale in pediatric emergency department patients. *Acad Emer Med*. 2010;17(1):50-54. doi: 10.1111/j.1553-2712.2009.00620.x. Epub 2009 Dec 9.
27. Berman A, Snyder S, Jackson C. Pain management. In: Berman A, Snyder S, Jackson C, eds. *Skills in Clinical Nursing*. 6th ed. Upper Saddle River, NJ: Pearson; 2009:247-289.
28. Dover G, Amar V. Development and validation of the athlete fear avoidance questionnaire. *J Athl Train.*

2015;50(6):634-642. doi: 10.4085/1062-6050-49.3.75. Epub 2015 Mar 20.
29. Herring SA, Kibler WB. A framework for rehabilitation. In: Kibler WB, Herring SA. Press JM. eds. *Functional Rehabilitation of Sports and Musculoskeletal Injuries*. Philadelphia, PA: Lippincott Williams & Wilkins; 1998
30. Standaert CJ, Herring SA, Pratt TW. Rehabilitation of the athlete with low back pain. *Curr Sports Med Rep*. 2004;3(1):35-40. doi:10.1249/00149619-200402000-00007.
31. Back Pain in Adolescent Athletes, Young, W 2011
32. Fritz JM, Cleland JA, Childs JD. Subgrouping patients with low back pain: evolution of a classification approach to physical therapy.. *J Orthop Sports Phys Ther*. 2007;37(6):290-302. Erratum *J Orthop Sports Phys Ther*. 2007;37(12):769.
33. Clifford SN. PhD thesis. Clinical presentation and treatment outcomes of children and adolescents with low back pain in physical therapy. 2009, School of Health and Rehabilitation Sciences, University of Pittsburgh.
34. Clifford SN, Fritz JM. Children and adolescents with low back pain: a descriptive study of physical examination and outcome measurement. *J Orthop Sports Phys Ther*. 2003;33(9):513-522.
35. Magee DJ. *Orthopedic Physical Assessment*. St. Louis, MO: Saunders Elsevier; 2014.
36. Hicks GE, Fritz JM, Delitto A, Mishock J. Interrater reliability of clinical examination measures for identification of lumbar segmental instability. *Arch Phys Med Rehabil*. 2003;84(12):1858-1864.
37. Bratton RL. Assessment and management of acute low back pain. *Am Fam Physician.* 1999;160(8):2299-2308.
38. Fritz JM, Piva SR, Childs JD. Accuracy of the clinical examination to predict radiographic instability of the lumbar spine. *Eur Spine J*. 2005;14(8):743-750.
39. Fritz JM, Whitman JM, Childs JD. Lumbar spine segmental mobility assessment: an examination of validity for determining intervention strategies in patients with low back pain. *Arch Phys Med Rehabil*. 2005;86(9):1745-1752.
40. van der Windt DA, Simons E, Riphagen II, et al. Physical examination for lumbar radiculopathy due to disc herniation in patients with low-back pain. *Cochrane Database Syst Rev*. 2010;2:CD007431. doi: 10.1002/14651858.CD007431.pub2.
41. Maitland GD. The slump test: examination and treatment. *Aust J Physiother*. 1985;31(6):215-219. doi:10.1016/s0004-9514(14)60634-6.
42. Hicks GE, 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.
43. Biering-Sørensen F. Physical measurements as risk indicators for low-back trouble over a one-year period. *Spine (Phila Pa 1976)*. 1984;9(2):106-119.
44. Waldheim A, Li L. Endurance tests are the most reliable core stability related measurements. *J Sport Health Sci*. 2012;1(2):121-128.
45. Berryman Resse N, Bandy WD. *Joint Range of Motion and Muscle Length Testing*. St. Louis, MO: Saunders Elsevier; 2010.
46. Youdas JW, Garret TR, Egan KS, Therneau TM. Lumbar lordosis and pelvic inclination in adults with chronic low back pain. *Phys Ther*. 2000;80(3):261-275.
47. Reiman MP, Krier AD, Nelson JA, Rogers MA, Stuke ZO, Smith BS. Comparison of different trunk endurance testing methods in college-aged individuals. *Int J Sports Phys Ther*. 2012;7(5):533-539.
48. Delitto A, George SZ, Van Dillen L, et al. Low back pain. *J Orthop Sports Phys Ther*. 2012;42(4):A1-57. doi:10.2519/jospt.2012.42.4.A1.
49. Ellison JB, Rose SJ, Sahrmann SA. Patterns of hip rotation range of motion: a comparison between healthy subjects and patients with low back pain. *Phys Ther*. 1990;70(9):537-541.
50. Godges JJ, MacRae PG, Engelke KA. Effects of exercise on hip range of motion, trunk muscle performance, and gait economy. *Phys Ther*. 1993;73(7):468-477.
51. Thorborg K, Bandholm T, Schick M, Jensen J, Hölmich P. Hip strength assessment using handheld dynamometry is subject to intertester bias when testers are of different sex and strength. *Scand J Med Sci Sports.* 2011;23(4):487-493. doi: 10.1111/j.1600-0838.2011.01405.x. Epub 2011 Oct 28.
52. Youdas JW, Mraz ST, Norstad BJ, Schinke JJ, Hollman JH. Determining meaningful changes in hip abductor muscle strength obtained by handheld dynamometry. *Physiother Theory Pract.* 2008;24(3):215-220. doi: 10.1080/03639040701429374.
53. Flynn T, Fritz J, Whitman J, et al. A clinical prediction rule for classifying patients with low back pain who demonstrate short-term improvement with spinal manipulation. *Spine (Phila Pa 1976).* 2002;27(24):2835-2843.
54. Cleland JA, Childs JD, Palmer JA, Eberhart S. Slump stretching in the management of non-radicular low back pain: a pilot clinical trial. *Man Ther*. 2006;11(4):279-286. doi: 10.1016/j.math.2005.07.002.
55. Hicks GE, Sions JM, Velasco TO, Manal TJ. Trunk muscle training augmented with neuromuscular electrical stimulation appears to improve function in older adults with chronic low back pain: a randomized preliminary trial. *Clin J Pain.* 2016;32(10):898-906. doi: 10.1097/AJP.0000000000000348.
56. Manal TJ. Use of electrical stimulation to supplement lumbar stabilization for a figure skater, Gregory CM,

Bickel CS. Recruitment patterns in human skeletal muscle during electrical stimulation. *Phys Ther*. 2005 Apr;85(4):358-364.
57. Fitzgerald GK, Piva SR, Irrgang J. A modified neuromuscular electrical stimulation protocol for quadriceps strengthening following anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther*. 2003;33(9):492-501.
58. Ayotte NW, Stetts DM, Keenan G, Greenway EH. Electromyographical analysis of selected lower extremity muscles during 5 unilateral weight-bearing exercises. *J Orthop Sports Phys Ther.* 2007;37(2):48-55.
59. Reiman MP, Bolgla LA, Loudon JK. A literature review of studies evaluating gluteus maximus and gluteus medius activation during rehabilitation exercises. *Physiother Theory Pract.* 2012;28(4):257-268. doi: 10.3109/09593985.2011.604981.
60. McGill S. Low back exercises: evidence for improving exercise regimens. *Phys Ther.* 1998;78(7):754-765.
61. Standaert CJ, Herring SA, Pratt TW. Rehabilitation of the athlete with low back pain. *Curr Sports Med Rep*. 2004;3(1):35-40
62. Muratori LM, Lamberg EM, Quinn L, Duff SV. Applying principles of motor learning and control to upper extremity rehabilitation. *J Hand Ther.* 2013;26(2):94-102; quiz 103.
63. Hodges PW. Core stability exercise in chronic low back pain. *Orthop Clin North Am*. 2003;34(2):245-254.
64. 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.
65. Carlson C. Axial back pain in the athlete: pathophysiology and approach to rehabilitation. *Curr Rev Musculoskelet Med*. 2009;2(2):88-93. doi: 10.1007/s12178-009-9050-y. Epub 2009 May 7.
66. Ivarsson A, Tranaeus U, Johnson U, Stenling A. Negative psychological responses of injury and rehabilitation adherence effects on return to play in competitive athletes: a systematic review and meta-analysis. *Open Access J Sports Med*. 2017;8:27-32. doi:10.2147/OAJSM.S112688.
67. Masiero S, Carraro E, Celia A, Sarto D, Ermani M. Prevalence of nonspecific low back pain in schoolchildren aged between 13 and 15 years. *Acta Paediatrica*. 2008;97(2):212-216. doi: 10.1111/j.1651-2227.2007.00603.x. Epub 2008 Jan 3.
68. Astfalck R, O'Sullivan P, Straker L, Smith A. A detailed characterisation of pain, disability, physical and psychological features of a small group of adolescents with non-specific chronic low back pain. *Man Ther*. 2010;15(3):240-247. doi: 10.1016/j.math.2009.12.007. Epub 2010 Jan 29.
69. Von Rosen P, Kottorp A, Fridén C, Frohm A, Heijne A. Young, talented and injured: Injury perceptions, experiences and consequences in adolescent elite athletes. *Eur J Sport Sci*. 2018;18(5):731-740. doi: 10.1080/17461391.2018.1440009. Epub 2018 Mar 3.
70. Bell DR, Post EG, Trigstead SM, Schaefer DA, McGuine TA, Brooks MA. Parents' awareness and perceptions of sport specialization and injury prevention recommendations. *Clin J Sport Med.* 2018. In Press. doi: 10.1097/JSM.0000000000000648.
71. Jayanthi NA, LaBella CR, Fischer D, Paulka J, Dugas LR. Sports-specialized intensive training and the risk of injury in young athletes: a clinical case-control study. *Am J Sports Med*. 2015;43(4):794-801. doi: 10.1177/0363546514567298. Epub 2015 Feb 2.
72. Post EG, Trigsted SM, Riekena JW, et al. The association of sport specialization and training volume with injury history in youth athletes. *Am J Sports Med*. 2017;45:1405-1412. doi: 10.1177/0363546517690848. Epub 2017 Mar 13.
73. Lowe TG. Scheuermann's kyphosis. *Neurosurg Clin North Am.* 2007;18(2):305-315.
74. Lowe TG. Scheuermann's disease. *Orthop Clin North Am*. 1999;30:475-487.
75. Bezalel T, Kalichman L. Improvement of clinical and radiographical presentation of Scheuermann disease after Schroth therapy treatment. *J Bodyw Mov Ther*. 2015;19(2):232-237. doi: 10.1016/j.jbmt.2014.04.008. Epub 2014 Apr 18.
76. Montgomery SP, Erwin WE. Scheuermann's kyphosis-long-term results of milwaukee brace treatment. *Spine (Phila Pa 1976).* 1981;6(1):5-8.
77. Bezalel T, Carmeli E, Been E, Kalichman L. Scheuermann's disease: current diagnosis and treatment approach. *J Back Musculoskelet Rehabil*. 2014;27(4):383-390.
78. Weinstein SL, Dolan LA, Cheng JC, Danielsson A, Morcuende JA. Adolescent idiopathic scoliosis. *Lancet.* 2008;371(9623):1527-1537. doi: 10.1016/S0140-6736(08)60658-3.
79. Janicki JA, Alman B. Scoliosis: review of diagnosis and treatment. *Paediatr Child Health.* 2007;12(9):771-776.
80. Kane WJ. Scoliosis prevalence: a call for a statement of terms. *Clin Orthop Relat Res*. 1977;126:43-46.
81. Reamy F, Slakey J. Adolescent indiopathic scioliosis: review and concepts. *Am Fam Physician*. 2001;64(1):111-116.
82. Screening for adolescent idiopathic scoliosis. Policy statement. US Preventive Services Task Force. *JAMA*. 1993;269:2664-2666.
83. van der Linden S, Valkenburg HA, Cats A. Evaluation of diagnostic criteria for ankylosing spondylitis. A proposal for modification of the New York Criteria. *Arthritis Rheum*. 1984;27(4):361-368.
84. Rudwaleit M, Kahn M, Sieper J. The challenge of diagnosis and classification in early ankylosing spondylitis: do

we need new criteria? *Arthritis Rheum.* 2005;52(4):1000-1008.
85. Raychaudhuri S, Deodhar A. The classification and diagnostic criteria of ankylosing spondylitis. *J Autoimmun*. 2014;48-49:128-133. doi: 10.1016/j.jaut.2014.01.015. Epub 2014 Feb 16.
86. Brophy S, Calin A. Ankylosing spondylitis: interaction between genes, joints, age at onset and disease expression. *J Rheumatol*. 2001;28(10):2283-2288.
87. Dagfinrud H, Fvien T, Hagen K. The Cochrane review of physiotherapy interventions for ankylosing spondylitis. *J Rheumatol*. 2005;32(10):1899-1906.