



The Relationship Between Movement and Pain

Independent Study
Course 29.1.1

Elizabeth A. V. Bloom, PT, DPT
University of Wisconsin Hospitals and Clinics
Madison, WI

CONTINUING PHYSICAL THERAPY EDUCATION

ACADEMY OF
**ORTHOPAEDIC
PHYSICAL THERAPY** 

 **APTA**
American Physical Therapy Association

REFERENCES

1. Hodges PW, Smeets RJ. Interaction between pain, movement, and physical activity: short-term benefits, long-term consequences, and targets for treatment. *Clin J Pain*. 2015;31(2):97-107. doi: 10.1097/AJP.0000000000000098.
2. O'Sullivan PB, Caneiro JP, O'Keefe M, et al. Cognitive Functional Therapy: an integrated behavioral approach for the targeted management of disabling low back pain. *Phys Ther*. 2018;98(5):408-423. doi: 10.1093/ptj/pzy022.
3. O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. *Man Ther*. 2005;10(4):242-255.
4. Hayden J, van Tulder M, Malmivaara A, Koes BW. Exercise therapy for treatment of non-specific low back pain. *Cochrane Database Syst Rev*. 2005;(3):CD000335.
5. Gurevich M, Kohn PM, Davis C. Exercise-induced analgesia and the role of reactivity in pain sensitivity. *J Sports Sci*. 1994;12(6):549-559.
6. Hodges PW, Tucker K. Moving differently in pain: a new theory to explain the adaptation to pain. *Pain*. 2011;152(3 Suppl):S90-S98.
7. Hauser W, Klose P, Langhorst J, et al. Efficacy of different types of aerobic exercise in fibromyalgia syndrome: a systematic review and meta-analysis of randomised controlled trials. *Arthritis Res Ther*. 2010;12(3):R79.
8. Koes BW, van Tulder MW, Thomas S. Diagnosis and treatment of low back pain. *BMJ*. 2006;332(7555):1430-1434.
9. Smeets R, Severens J, Beelen S, Vlaeyen JW, Knottnerus JA. More is not always better: cost-effectiveness analysis of combined, single behavioral and single physical rehabilitation programs for chronic low back pain. *Eur J Pain*. 2009;13(1):71-81. doi: 10.1016/j.ejpain.2008.02.008. Epub 2008 Apr 22.
10. Dahm K, Brurberg K, Jamtvedt G, Hagen KB. Advice to rest in bed versus advice to stay active for acute low-back pain and sciatica. *Cochrane Database Syst Rev*. 2010;(6):CD007612. doi: 10.1002/14651858.CD007612.pub2.
11. van Middelkoop M, Rubinstein S, Verhagen A, Ostelo RW, Koes BW, van Tulder MW. Exercise therapy for chronic nonspecific low-back pain. *Best Pract Res Clin Rheumatol*. 2010;24(2):193-204. doi: 10.1016/j.berh.2010.01.002.
12. Airaksinen O, Brox JI, Cedraschi C, et al. Chapter 4. European guidelines for the management of chronic nonspecific low back pain. *Eur Spine J*. 2006;15(suppl 2):S192-S300.
13. Sluka K, O'Donnell J, Danielson J, Rasmussen LA. Regular physical activity prevents development of chronic pain and activation of central neurons. *J Appl Physiol (1985)*. 2013;114(6):725-733. doi: 10.1152/jappphysiol.01317.2012. Epub 2012 Dec 27.
14. Nijs J, Kosek E, Van Oosterwijck J, Meeus M. Dysfunctional endogenous analgesia during exercise in patients with chronic pain: to exercise or not to exercise? *Pain Physician*. 2012;15(3 Suppl):ES205-ES213.
15. Cote JN, Hoeger Bement MK. Update on the relation between pain and movement: consequences for clinical practice. *Clin J Pain*. 2010;26(9):754-762.
16. O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. *Man Ther*. 2005;10(4):242-255.
17. Tsao H, Galea MP, Hodges PW. Reorganization of the motor cortex is associated with postural control deficits in recurrent low back pain. *Brain*. 2008;131(Pt 8):2161-2171. doi: 10.1093/brain/awn154. Epub 2008 Jul 18.
18. Hall T, Elvey R. Nerve trunk pain: physical diagnosis and treatment. *Man Ther*. 1999;4(2):63-73.
19. Wall P, McMahon S. The relationship of perceived pain to afferent nerve impulses. *Trends Neurosci*. 1986;9:254-255.
20. Svensson P, Houe L, Arendt-Nielsen L. Bilateral experimental muscle pain changes electromyographic activity of human jaw-closing muscles during mastication. *Exp Brain Res*. 1997;116(1):182-185.
21. Graven-Nielsen T, Lund H, Arendt-Nielsen L, Daneskiold-Samsøe B, Bliddal H. Inhibition of maximal voluntary contraction force by experimental muscle pain: a centrally mediated mechanism. *Muscle Nerve*. 2002;26(5):708-712.
22. Svensson P, Macaluso GM, De Laat A, Wang K. Effects of local and remote muscle pain on human jaw reflexes evoked fast stretches at different clenching levels. *Exp Brain Res*. 2001;139(4):495-502.
23. Arendt-Nielsen L, Graven-Nielsen T, Sværre H, Svensson P. The influence of low back pain on muscle activity and coordination during gait: a clinical and experimental study. *Pain*. 1996;64(2):231-240.
24. 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 Pt2:591-604.
25. Graven-Nielsen T, Svensson P, Arendt-Nielsen L. Effects of experimental muscle pain on muscle activity and co-ordination during static and dynamic motor function. *Electroencephalogr Clin Neurophysiol*. 1997;105(2):156-164.

26. Farina D, Arendt-Nielsen L, Graven-Nielsen T. Experimental muscle pain reduces initial motor unit discharge rates during sustained submaximal contractions. *J Appl Physiol* (1985). 2005;98(3):999-1005.
27. Roland MO. A critical review of the evidence for a pain-spasm-pain cycle in spinal disorders. *Clin Biomech (Bristol, Avon)*. 1986;1(2):102-109. doi: 10.1016/0268-0033(86)90085-
28. Johansson H, Sojka P. Pathophysiological mechanisms involved in genesis and spread of muscular tension in occupational muscle pain and in chronic musculoskeletal pain syndromes: a hypothesis. *Med Hypotheses*. 1991;35(3):196-203.
29. Wang K, Arendt-Nielsen L, Svensson P. Excitatory actions of experimental muscle pain on early and late components of human jaw stretch reflexes. *Arch Oral Biol*. 2001;46(5):433-442.
30. Wang K, Arima T, Arendt-Nielsen L, Svensson P. EMG-force relationships are influenced by experimental jaw-muscle pain. *J Oral Rehabil*. 2000;27(5):394-402.
31. Matre DA, Sinkjaer T, Svensson P, Arendt-Nielsen L. Experimental muscle pain increases the human stretch reflex. *Pain*. 1998;75(2-3):331-339.
32. Thunberg J, Ljubisavljevic M, Djupsjobacka M, Johansson H. Effects on the fusimotor-muscle spindle system induced by intramuscular injections of hypertonic saline. *Exp Brain Res*. 2002;142(3):319-326.
33. Del Santo F, Gelli F, Spidalieri R, Rossi A. Corticospinal drive during painful voluntary contractions at constant force output. *Brain Res*. 2007;1128(1):91-98.
34. Sessle BJ. Neural mechanisms and pathways in craniofacial pain. *Can J Neurol Sci*. 1999;26 Suppl 3:S7-11.
35. Farina D, Arendt-Nielsen L, Graven-Nielsen T. Experimental muscle pain decreases voluntary EMG activity but does not affect the muscle potential evoked by transcutaneous electrical stimulation. *Clin Neurophysiol*. 2005;116(7):1558-1565.
36. Matre DA, Sinkjaer T, Knardahl S, Andersen JB, Arendt-Nielsen L. The influence of experimental muscle pain on the human soleus stretch reflex during sitting and walking. *Clin Neurophysiol*. 1999;110(12):2033-2043.
37. Lund JP, Donga R, Widmer CG, Stohler CS. The pain-adaptation model: a discussion of the relationship between chronic musculoskeletal pain and motor activity. *Can J Physiol Pharmacol*. 1991;69(5):683-694.
38. Vlaeyen J, Linton S. Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art. *Pain*. 2000;85(3):317-332.
39. Hasenbring M, Verbunt J. Fear-avoidance and endurance related responses to pain: new models of behavior and their consequences for clinical practice. *Clin J Pain*. 2010;26(9):747-753. doi: 10.1097/AJP.0b013e3181e104f2.
40. Tucker K, Hodges PW. Motoneurone recruitment is altered with pain induced in non-muscular tissue. *Pain*. 2009;141(1-2):151-155. doi: 10.1016/j.pain.2008.10.029. Epub 2008 Dec 17.
41. Tucker K, Butler J, Graven-Nielsen T, Riek S, Hodges P. Motor unit recruitment strategies are altered during deep-tissue pain. *J Neurosci*. 2009;29(35):10820-10826. doi: 10.1523/JNEUROSCI.5211-08.2009.
42. Philips H, Jahanshani M. The components of pain behavior report. *Behav Res Ther*. 1987;24(2):117-125.
43. Hasenbring M, Marienfeld G, Kuhlendahl D, Soyka D. Risk factors of chronicity in lumbar disc patients. A prospective investigation of biologic, psychological, and social predictors of therapy outcome. *Spine*. 1994;19(24):2759-2765.
44. McCracken LM, Zayfert C, Gross RT. The pain anxiety symptoms scale: development and validation of a scale to measure fear of pain. *Pain*. 1992;50(1):67-73.
45. Waddell G, Newton M, Henderson I, Somerville D, Main CJ. A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. *Pain*. 1993;52(2):157-168.
46. Rosenstiel AK, Keefe FJ. The use of coping strategies in chronic low back pain patients: relationship to patient characteristics and current adjustment. *Pain*. 1983;17(1):33-44.
47. Hasenbring M. Endurance strategies-a neglected phenomenon in the research and therapy of chronic pain? *Schmerz*. 1993;7(4):304-313.
48. Grebner M, Breme K, Rothoerl R, Woertgen C, Hartmann A, Thomé C. Coping and convalescence course after lumbar disk operations. *Schmerz*. 1999;13(1):19-30.
49. Garcia-Campayo JG, Pascual A, Alda M, Gonzalez Ramirez MT. Coping with fibromyalgia: usefulness of the chronic pain coping inventory-42. *Pain*. 2007;132 Suppl 1:S68-S76.
50. Malik B, Whittle T, Ogawa T, Murray GM. Reorganization of motor unit activity at different sites within the human masseter muscle during experimental masseter pain. *Eur J Oral Sci*. 2018;126(5):400-410. doi: 10.1111/eos.12561. Epub 2018 Jul 30.
51. Murray G, Peck CC. Orofacial pain and jaw muscle activity: a new model. *J Orofac Pain*. 2007;21(4):263-278; discussion 279-288.
52. van Dieen J, Selen L, Cholewicki J. Trunk muscle activation in low-back pain patients, an analysis of the literature. *J Electromyogr Kinesiol*. 2003;13(4):333-351.
53. Ehrsson HH, Wiech K, Weiskopf N, Dolan RJ, Passingham RE. Threatening a rubber hand that you feel is yours elicits a cortical anxiety response. *Proc Natl Acad Sci U S A*. 2007;104(23):9828-9833.
54. Sturzenegger M, Radanov BP, Di Stefano G. The effect of accident mechanisms and initial findings on

- the long-term course of whiplash injury. *J Neurol*. 1995;242(7):443-449.
55. Gallagher KM, Nelson-Wong E, Callaghan JP. Do individuals who develop transient low back pain exhibit different postural changes than non-pain developers during prolonged standing? *Gait Posture*. 2011;34(4):490-495. doi: 10.1016/j.gaitpost.2011.06.025. Epub 2011 Jul 29.
 56. Moseley GL, Hodges PW. Reduced variability of postural strategy prevents normalization of motor changes induced by back pain: a risk factor for chronic trouble? *Behav Neurosci*. 2006;120(2):474-476. doi: 10.1037/0735-7044.120.2.474.
 57. van Dillen L, Gombatto S, Collins D, Engsberg JR, Sahrman SA. Symmetry of timing of hip and lumbopelvic rotation motion in 2 different subgroups of people with low back pain. *Arch Phys Med Rehabil*. 2007;88(3):351-360.
 58. Hodges PW, Heijnen I, Gandevia SC. Postural activity of the diaphragm is reduced in humans when respiratory demand is increased. *J Physiol*. 2001;537(Pt 3):999-1008.
 59. Hodges PW, Coppiters MW, MacDonald D, Cholewicki J. New insight into motor adaptation to pain revealed by a combination of modeling and empirical approaches. *Eur J Pain*. 2013;17(8):1138-1146. doi: 10.1002/j.1532-2149.2013.00286.x. Epub 2013 Jan 25.
 60. van Damme S, Legrain V, Vogt J, Crombez G. Keeping pain in mind: a motivational account of attention to pain. *Neurosci Biobehav Rev*. 2010;34(2):204-213.
 61. 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.
 62. Moseley GL, Nicholas MK, Hodges PW. Does anticipation of back pain predispose to back trouble? *Brain*. 2004;127(Pt 10):2339-2347.
 63. Fick R. *Handbook de Anatomie und Mechanik der Gelenke*, vol 3. Jena, Gustav Fischer, 1911.
 64. Watson PJ, Booker CK, Main CJ, Chen AC. Surface electromyography in the identification of chronic low back pain patients: the development of the flexion relaxation ratio. *Clin Biomech (Bristol, Avon)*. 1997;12(3):165-171.
 65. Hodges PW, Holm AK, Hansson T, Holm S. Rapid atrophy of the lumbar multifidus follows experimental disc or nerve root injury. *Spine (Phila Pa 1976)*. 2006;31(25):2926-2933.
 66. Hides JA, Stokes MJ, Saide M, Jull GA, Cooper DH. Evidence of lumbar multifidus muscle wasting ipsilateral to symptoms in patients with acute/subacute low back pain. *Spine (Phila Pa 1976)*. 1994;19(2):165-172.
 67. Barker KL, Shamley DR, Jackson D. Changes in the cross-sectional area of multifidus and psoas in patients with unilateral back pain: the relationship to pain and disability. *Spine (Phila Pa 1976)*. 2004;29(22):E515-E519.
 68. Smeets RJ, Wade D, Hidding A, Van Leeuwen PJ, Vlaeyen JW, Knottnerus JA. The association of physical deconditioning and chronic low back pain: a hypothesis-oriented systematic review. *Disabil Rehabil*. 2006;28(11):673-693.
 69. Woolf CJ. Dissecting out mechanisms responsible for peripheral neuropathic pain: implications for diagnosis and therapy. *Life Sci*. 2004;74(21):2605-2610.
 70. Kim HJ, Moon WJ, Oh J, Lee IK, Kim HY, Han SH. Subthalamic lesion on MR imaging in a patient with nonketotic hyperglycemia-induced hemiballism. *AJNR Am J Neuroradiol*. 2008;29(3):526-527. doi: 10.3174/ajnr.A0927. Epub 2008 Jan 9.
 71. Boyd BS, Wanek L, Gray AT, Topp KS. Mechanosensitivity of the lower extremity nervous system during straight-leg raise neurodynamic testing in healthy individuals. *J Orthop Sports Phys Ther*. 2009;39(11):780-790. doi: 10.2519/jospt.2009.3002.
 72. Coppiters MW, Alshami AM, Babri AS, Souvlis T, Kippers V, Hodges PW. Strain and excursion of the sciatic, tibial, and plantar nerves during a modified straight leg raising test. *J Orthop Res*. 2006;24(9):1883-1889.
 73. Moseley GL, Butler DS. Supercharge your pain biology. In: Moseley GL, Butler DS, eds. *Explain Pain Supercharged*. Adelaide City West, South Australia: Noigroup Publications; 2017:37-77.
 74. Wall PD, Woolf CJ. What we don't know about pain. *Nature*. 1980;287(5779):185-186.
 75. Woolf CJ. Evidence for a central component of post-injury pain hypersensitivity. *Nature*. 1983;306(5944):686-688.
 76. Moseley GL, Butler DS. Fifteen years of explaining pain: the past, present, and future. *J Pain*. 2015;16(9):807-813. doi: 10.1016/j.jpain.2015.05.005. Epub 2015 Jun 5.
 77. Moseley GL, Vlaeyen JW. Beyond nociception: the imprecision hypothesis of chronic pain. *Pain*. 2015; 156(1):35-38. doi: 10.1016/j.pain.0000000000000014.
 78. Kosek E, Ekholm J, Hansson P. Increased pressure pain sensibility in fibromyalgia patients is located deep to the skin but not restricted to muscle tissue. *Pain*. 1995;63(3):335-339.
 79. Woolf CJ. What to call the amplification of nociceptive signals in the central nervous system that contribute to widespread pain? *Pain*. 2014;155(10):1911-1912. doi: 10.1016/j.pain.2014.07.021. Epub 2014 Jul 30.
 80. Flor H, Elbert T, Knecht S, et al. Phantom-limb pain as a perceptual correlate of cortical reorganization following arm amputation. *Nature*. 1995;375(6531):482-484.

81. Henriksen M, Hansen JB, Klokke L, Bliddal H, Christensen R. Comparable effects of exercise and analgesics for pain secondary to knee osteoarthritis: a meta-analysis of trials included in Cochrane systematic reviews. *J Comp Eff Res*. 2016;5(4):417-431. doi: 10.2217/cer-2016-0007. Epub 2016 Jun 27.
82. Koltyn KF. Analgesia following exercise: a review. *Sports Med*. 2000;29(2):85-98.
83. Colt EW, Wardlaw SL, Frantz AG. The effect of running on plasma beta-endorphin. *Life Sci*. 1981;28(14):1637-1640.
84. Sforzo GA. Opioids and exercise. An update. *Sports Med*. 1989;7(2):109-124.
85. Smart KM, Blake C, Staines A, Doody C. The discriminative validity of “nociceptive,” “peripheral neuropathic,” and “central sensitization” as mechanisms-based classifications of musculoskeletal pain. *Clin J Pain*. 2011;27(8):655-663. doi: 10.1097/AJP.0b013e-318215f16a.
86. Sahrman S. *Diagnosis and Treatment of Movement Impairment Syndromes*. St. Louis, MO: Mosby Inc; 2002.
87. Kolber MJ, Hanney WJ. The dynamic disc model: a systematic review of the literature. *Phys Ther Rev*. 2009;14(3):181-189.
88. McKenzie RA. *The Lumbar Spine: Mechanical Diagnosis and Therapy*. Waikanae, NZ: Spinal Publications New Zealand Ltd., 1981.
89. Vibe Fersum K, O’Sullivan P, Skouen JS, Smith A, Kvale A. Efficacy of classification-based cognitive functional therapy in patients with non-specific chronic low back pain: a randomized controlled trial. *Eur J Pain*. 2013;17(6):916-928. doi: 10.1002/j.1532-2149.2012.00252.x. Epub 2012 Dec 4.
90. Long A, Donelson R, Fung T. Does it matter which exercise? A randomized control trial of exercise for low back pain. *Spine (Phila Pa 1976)*. 2004;29(23):2593-2602.
91. Hides JA, Jull GA, Richardson CA. Long-term effects of specific stabilizing exercises for first-episode low back pain. *Spine (Phila Pa 1976)*. 2001;26(11):E243-248.
92. O’Sullivan PB, Phytty GD, Twomey LT, Allison GT. Evaluation of specific stabilizing exercise in the treatment of chronic low back pain with radiologic diagnosis of spondylolysis or spondylolisthesis. *Spine (Phila Pa 1976)*. 1997;22(24):2959-2967.
93. Stuge B, Veierod MB, Laerum E, Vollestad 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 (Phila Pa 1976)*. 2004;29(10):E197-203.
94. Macedo LG, Latimer J, Maher CG, et al. Effect of motor control exercises versus graded activity in patients with chronic nonspecific low back pain: a randomized controlled trial. *Phys Ther*. 2012;92(3):363-377. doi: 10.2522/ptj.20110290. Epub 2011 Dec 1.
95. Macedo LG, Maher CG, Latimer J, McAuley JH. Motor control exercise for persistent, nonspecific low back pain: a systematic review. *Phys Ther*. 2009;89(1):9-25. doi: 10.2522/ptj.20080103. Epub 2008 Dec 4.
96. Ferreira PH, Ferreira ML, Maher CG, Herbert RD, Refshauge K. Specific stabilisation exercise for spinal and pelvic pain: a systematic review. *Aust J Physiother*. 2006;52(2):79-88.
97. Apeldoorn AT, Ostelo RW, van Helvoirt H, et al. A randomized controlled trial on the effectiveness of a classification-based system for subacute and chronic low back pain. *Spine (Phila Pa 1976)*. 2012;37(16):1347-1356. doi: 10.1097/BRS.0b013e31824d9f2b.
98. Machado LA, Maher CG, Herbert RD, Clare H, McAuley JH. The effectiveness of the McKenzie method in addition to first-line care for acute low back pain: a randomized controlled trial. *BMC Med*. 2010;8:10. doi: 10.1186/1741-7015-8-10.
99. Nicholas MK, Asghari A, Corbett M, et al. Is adherence to pain self-management strategies associated with improved pain, depression and disability in those with disabling chronic pain? *Eur J Pain*. 2012;16(1):93-104. doi: 10.1016/j.ejpain.2011.06.005.
100. Miles CL, Pincus T, Carnes D, et al. Can we identify how programmes aimed at promoting self-management in musculoskeletal pain work and who benefits? A systematic review of sub-group analysis within RCTs. *Eur J Pain*. 2011;15(8):775.e1-11. doi: 10.1016/j.ejpain.2011.01.016. Epub 2011 Feb 26.
101. Smeets RJ, Vlaeyen JW, Kester AD, Knottnerus JA. Reduction of pain catastrophizing mediates the outcome of both physical and cognitive-behavioral treatment in chronic low back pain. *J Pain*. 2006;7(4):261-271.
102. Wideman TH, Asmundson GG, Smeets RJ, et al. Rethinking the fear avoidance model: toward a multidimensional frame work of pain-related disability. *Pain*. 2013;154(11):2262-2265. doi: 10.1016/j.pain.2013.06.005. Epub 2013 Jun 6.
103. Leeuw M, Goossens ME, van Breukelen GJ, et al. Exposure in vivo versus operant graded activity in chronic low back pain patients: results of a randomized controlled trial. *Pain*. 2008;138(1):192-207. doi: 10.1016/j.pain.2007.12.009. Epub 2008 Feb 1.
104. Linton SJ, Boersma K, Jansson M, Overmeer T, Lindblom K, Vlaeyen JW. A randomized controlled trial of exposure in vivo for patients with spinal pain reporting fear of work-related activities. *Eur J Pain*. 2008;12(6):722-730.
105. de Jong JR, Vlaeyen JW, de Gelder JM, Patijn J. Pain-related fear, perceived harmfulness of activities, and functional limitations in complex regional pain syndrome type I. *J Pain*. 2011;12(12):1209-1218. doi: 10.1016/j.jpain.2011.06.010. Epub 2011 Oct 26.

106. de Jong JR, Vlaeyen JW, Onghena P, Cuyppers C, den Hollander M, Ruijgrok J. Reduction of pain related fear in complex regional pain syndrome type 1: the application of graded exposure in vivo. *Pain*. 2005;116(3):264-275.
107. Samitz G, Egger M, Zwahlen M. Domains of physical activity and all-cause mortality: systematic review and dose-response meta-analysis of cohort studies. *Int J Epidemiol*. 2011;40(5):1382-1400. doi: 10.1093/ije/dyr112. Epub 2011 Sep 5.
108. Lin CW, McAuley JH, Macedo L, Barnett DC, Smeets RJ, Verbunt JA. Relationship between physical activity and disability in low back pain: a systematic review and meta-analysis. *Pain*. 2011;152(3):607-613. doi: 10.1016/j.pain.2010.11.034. Epub 2011 Jan 19.
109. Smeets RJ, Wittink H. The deconditioning paradigm for chronic low back pain unmasked? *Pain*. 2007;130(3):201-202.
110. Verbunt JA, Smeets RJ, Wittink HM. Cause or effect? Deconditioning and chronic low back pain. *Pain*. 2010;149(3):428-430. doi: 10.1016/j.pain.2010.01.020. Epub 2010 Feb 12.
111. Nijs J, Apeldoorn A, Hallegraef H, et al. Low back pain: guidelines for the clinical classification of predominant, neuropathic, nociceptive, or central sensitization pain. *Pain Physician*. 2015;18(3):E333-346.
112. O'Connell NE, Cook CE, Wand BM, Ward SP. Clinical guidelines for low back pain: A critical review of consensus and consistencies across three major guidelines. *Best Pract Res Clin Rheumatol*. 2016;30(6):968-980. doi: 10.1016/j.berh.2017.05.001. Epub 2017 Jun 9.
113. Lin I, Wiles LK, Waller R, et al. Poor overall quality of clinical practice guidelines for musculoskeletal pain: a systematic review. *Br J Sports Med*. 2018;52(5):337-343. doi: 10.1136/bjsports-2017-098375. Epub 2017 Nov 25.
114. Macedo LG, Smeets RJ, Maher CG, Latimer J, McAuley JH. Graded activity and graded exposure for persistent nonspecific low back pain: a systematic review. *Phys Ther*. 2010;90(6):860-879. doi: 10.2522/ptj.20090303. Epub 2010 Apr 15.
115. Heneweer H, Vanhees L, Picavet HS. Physical activity and low back pain: a u-shaped relation? *Pain*. 2009;143(1-2):21-25. doi: 10.1016/j.pain.2008.12.033. Epub 2009 Feb 12.
116. Whiteside A, Hansen S, Chaudhuri A. Exercise lowers pain threshold in chronic fatigue syndrome. *Pain*. 2004;109(3):497-499.
117. Meeus M, Roussel N, Truijen S, Nijs J. Reduced pressure pain thresholds in response to exercise in chronic fatigue syndrome but not in chronic low back pain: An experimental study. *J Rehab Med*. 2010;42(9):884-890. doi: 10.2340/16501977-0595.
118. Van Oosterwijck J, Nijs J, Meeus M, et al. Pain inhibition and post-exertional malaise in myalgic encephalomyelitis/chronic fatigue syndrome: an experimental study. *J Intern Med*. 2010;268(3):265-278. doi: 10.1111/j.1365-2796.2010.02228.x. Epub 2010 Mar 3.
119. Teasell RW, McClure JA, Walton D, et al. A research synthesis of therapeutic interventions for whiplash-associated disorder (WAD): part 4 - noninvasive interventions for chronic WAD. *Pain Res Manag*. 2010;15(5):313-322.
120. Van Oosterwijck J, Nijs J, Meeus M, Van Loo M, Paul L. Lack of endogenous pain inhibition during exercise in patients with chronic whiplash associated disorders: An experimental study. *J Pain*. 2012;13(3):242-254. doi: 10.1016/j.jpain.2011.11.006. Epub 2012 Jan 24.
121. Hides JA, Richardson CA, Jull GA. Multifidus muscle recovery is not automatic after resolution of acute, first-episode low back pain. *Spine (Phila Pa 1976)*. 1996;21(23):2763-2769.
122. Hodges PW, Richardson 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.
123. MacDonald D, Moseley GL, Hodges PW. Why do some patients keep hurting their back? Evidence of ongoing back muscle dysfunction during remission from recurrent back pain. *Pain*. 2009;142(3):183-188. doi: 10.1016/j.pain.2008.12.002. Epub 2009 Jan 30.
124. Nijs J, Daenen L, Cras P, Struyf F, Roussel N, Oostendorp RA. Nociception affects motor output: a review on sensory-motor interaction with focus on clinical implications. *Clin J Pain*. 2012;28(2):175-181. doi: 10.1097/AJP.0b013e318225daf3.
125. Hodges PW, Moseley GL. Pain and motor control of the lumbopelvic region: effect and possible mechanisms. *J Electromyogr Kinesiol*. 2003;13(4):361-70.