Correlation between lumbar stability level and postural sway in patients with non-specific chronic low back pain: a pilot study

Apinkarn Jaroenlarp*, Pitsinee Fuengjit, Jirapat Sukeeyuti, Parichart Sophap and Chadarat Chirasaengthong

Faculty of physical therapy and sport medicine, Rangsit University, Pathumthani, Thailand
*Corresponding author, E-mail: apinkarn.j@rsu.ac.th

Abstract

This study aimed to investigate the correlation between the level of modified isometric lumbar stability (MIST) and postural sway in anteroposterior (sagittal plane) and mediolateral (coronal plane). The findings should be used in the clinic to predict the problems and select the appropriate instrument in a patient with back pain. Twenty participants with non-specific chronic low back pain (NCLBP) aged 20 to 55 years were recruited. The level of MIST, sway area, and sway velocity were evaluated. The MIST consisted of six levels of difficulty. The participants performed a test of stability level as high as they could do without pain. Moreover, the postural control was measured by an accelerometer at the beginning of the exercise. The sway area and sway velocity were assessed in sitting on balance foam for 1 minute. The results showed high correlation between the level of MIST and sway area in both sagittal plane (r = -0.692, $p < 0.05$) and coronal plane (r = -0.740, $p < 0.05$). In addition, the results found correlation between levels of lumbar stability and sway velocity in coronal and sagittal plane (r = -0.850, $p < 0.05$ and r = -0.608, $p < 0.05$ respectively). The level of MIST can be used to predict postural sway in patients with NCLBP. High value for sway variables represented poor ability to maintain trunk control. Moreover, if the participants had a low level of MIST, they had poor postural control in both sagittal and coronal plane. The result of this study should confirm with a larger sample in the future.

Keywords: *chronic low back pain, core stabilization exercise, level of lumbar stability, postural sway*

1. Introduction

Low back pain (LBP) is a common problem of musculoskeletal disease. The epidemiology of LBP was reported that over 84% of the total population had back pain symptom at least once in their lifetime (Guo, Chang, Yeh, Chen, & Guo, 2004; Nachemson & Andersson, 1982). The LBP was found high prevalence in workers whose ages ranged from 35-64 years (Guo et al., 2004; Van Tulder et al., 2006). In Thailand, the prevalence of LBP was illustrated around 46.6%-71.3% of the musculoskeletal disorders (Keawduangdee, Puntumetakul, Boonprakob, Wanpen, & Siritaratiwat, 2010). The patients with LBP had many disabilities such as pain and poor activities of daily living that affects society, work, economic and quality of life (Costa et al., 2009; Gheldof, Vinck, Vlaeyen, Hidding, & Crombez, 2005; Ogunbode, Adebusoye, & Alonge, 2013). Non-specific chronic low back pain (NCLBP) is the most common types found in the LBP population (Andersson, 1999). The symptoms of NCLBP cannot be identified into a specific disease and not related to back pain from serious disease (Childs et al., 2008; Chou et al., 2007). This type of LBP excludes red flag diseases such as radicular syndrome due to a slipped disc, malignancy, vertebral fracture, stenosis, spondylitis, and severe spondylolisthesis. The patients with NCLBP had delayed time of core muscles contraction such as transversus abdominis resulting in poor trunk stability while performing a function (Costa et al., 2009; O'sullivan, Phyty, Twomey, & Allison, 1997).

The stability is coordination between trunk stability and lumbopelvic stability. The coordination of trunk control and lumbopelvic control is very important to perform a function in daily (Hodges, 2003; Willardson, 2007). The spinal stability is important to increase the performance of extremities movement, decrease loads on the lumbar spine. Spinal stability depends not only on the muscles but also on the central nervous system (CNS) (Panjabi, 1992). The spinal stabilizing system consisted of three subsystems that work together to control body stability: passive, act

ive, and neural subsystems. The passive subsystem is non-contractile structures such as the joint, capsules, ligaments, and articular structures. This system produces stability to the spine by reactive force to control the spine in a neutral position. The active subsystem consists of contractile structures such as muscles and tendons. This subsystem can be divided into global and local muscle groups. The local muscle is the main to control spinal stability, prevent injury of the lumbar spine from over force and loads on the lumbar spine (Bergmark, 1989). The last subsystem is a neural system. The neural subsystem received a signal from nerve, ligaments, CNS, muscles spindles, Golgi tendon organs, and ligaments. The neural subsystem must work together with postural adjustments to control external loads and body stability. The neural subsystem is necessary to stabilize against the forces from extremity movements by feedforward activation and early recruitment (Janda, 1978). The three subsystems that worked together to control body stability (Bergmark, 1989; Willardson, 2007). In the patients with LBP had poor function of transversus abdominis resulting to loss of stability and functional ability (Costa et al., 2009). Moreover, the patients with LBP had poor CNS control and delayed feedforward activation of core muscles (Costa et al., 2009; Janda, 1978).

The modified isometric stability test (MIST) is a tool used for measuring the level of lumbar stability (Hagins, Adler, Cash, Daugherty, & Mitrani, 1999). This tool demonstrated good intra-rater and inter-rater reliability (Wohlfahrt, Jull, & Richardson, 1993). This test used for measuring the stability of the lumbar spine by isometric contractions of the transversus abdominis. The MIST is aimed to control core muscles contraction monitored by the pressure biofeedback unit. The pressure biofeedback was placed on the lower back between the posterior superior iliac spine (PSIS). The patients performed abdominal drawing with holding stability of the pelvis and trunk without movement. This test consists of 1 to 6 levels while progressively adding loads by movements of the lower limb.

The postural stability is a one of postural balance described by the ability to control posture in the base of support with minimal trunk motion (Cho, Lee, Lee, Lee, & Lee, 2014; Palmieri, Ingersoll, Stone, & Krause, 2002). The postural sway composes of trunk control with movements of the extremities in the body’s center of mass (Janda, 1978). The patients with LBP have poor postural stability than healthy people. In addition, people with poor postural stability have high risk of a LBP (Mok, Brauer, & Hodges, 2004). People with LBP were found that the loss of somatosensory information has been affecting their postural stability. Moreover, LBP patients had high sway amplitude and sway velocity that suggest a decreased ability to maintain postural control during performing a function in daily living (Nies & Sinnott, 1991).

The patient with NCLBP had pain and dysfunction of the lower lumber. The core stabilization exercise helps to decrease pain and improve stability in patients with NCLBP. Before exercise, choosing an appropriate level of exercise position is very important in preventing an injury. If the level of exercise is more difficult, it may cause an injury or high load on the lumbar spine (Hagins et al., 1999). The level of stability can be used to evaluate the performance of the patient, and it is easy to use. If the MIST level can predict the postural sway, it should be used in the clinic to predict the problems and choose exercise position to increase core muscle activity in patients. Therefore, this study was aimed to determine the correlation of the MIST scores and the postural sway in the coronal and sagittal plane. If the two variables are related, it can apply to select exercise position and speculate problems in the patients with LBP. In addition, the results from this study can be used to plan treatment for decreasing of LBP.

2. Objectives

The purpose of this study was to examine the correlation between lumbar stability level and the postural sway in the patients with NCLBP.

3. Materials and Methods

3.1 Participants

Twenty participants with NCLBP participated in this study and signed an inform consent prior to participating in this study. Ethical approval was permitted by the Ethical Committee of Rangsit University, Thailand. The inclusion criteria were individuals whose ages ranged from 20-55 years and had NCLBP symptoms. All participants had symptoms of NCLBP according to criteria (Childs et al., 2008; Chou et al., 2007). The NCLBP is back pain between the costal margin and not below the gluteal fold. The NCLBP symptom is the unclear cause of back pain and the symptoms are unrelated to specific or underlying diseases. The exclusion criteria included past history of back and abdomen surgery, fractures of the spine, hip or lower limb, as well as pain intensity of more than 60 of 100 millimeters as measured by visual analog scale (VAS). Moreover, they did not have LBP with a red flag such as trauma, tumor cancer, infection, and cauda equine syndrome. These red flag diseases were excluded by subjective and objective examination as well as an evaluation form.

3.2 Procedures

All participants were tested the six levels of lumbar stability (MIST) with pressure biofeedback unit and postural stability. The MIST levels were increased from easy to difficult. The lumbar stability level was evaluated by the MIST with the pressure biofeedback unit (PBU). The PBU was used to determine the lumbopelvic control and local muscles control for each level. The participants were asked to lie on back with knees bent and performed the abdominal hollowing without moving of the spine and pelvis. The participants performed abdominal hollowing with normal breathing and don't holds breathe. The PBU was placed between posterior superior iliac spines that under the lower back. The level of lumbar stability was consists of six levels, each level the patient was asked to control the pressure at 40 ± 4 mmHg for three breathing cycles spine (Hagins et al., 1999). In each level, the participants performed abdominal contraction while exhaling. The researcher instructed to perform the abdominal drawing and control lumbar and pelvic in a static position for three breathing cycles. The MIST level consisted of six levels (Figure 1);

Level 1: abdominal contraction
Level 2: abdominal contraction with abducting the right leg to approximately 45 degrees
Level 3: abdominal contraction with extending the right knee joint with both thighs in the same level
Level4: abdominal contraction with raising the right leg toward the chest until the hip was bent approximately 90 degrees
Level 5: abdominal contraction with raising the right leg toward the chest until the hip was bent approximately 90 degrees and raising another leg to the same level
Level 6: abdominal contraction with raising both legs toward the chest until the hip was bent approximately 90 degrees

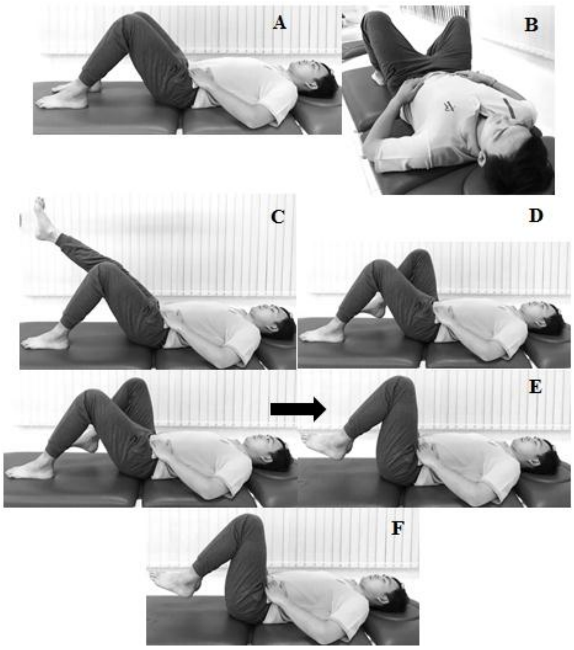


Figure 1 Lumbar stability level; A=Level 1, B=Level 2, C= Level 3, D= Level 4, E= Level 5 and F= Level 6

The postural stability was measured by accelerometer. The participants were asked to sit on a chair with balance form, hips and knees bent approximately 90 degrees and feet flat on the floor or stable surface (Figure 2). The participants sit on the chair with both arms cross over their chest. The sensor was placed on the lower lumbar at the spinous process of L5. The participants were instructed to sit without sway as much as they can do for 1 minute. The sway area and sway velocity in anteroposterior (sagittal plane) and mediolateral (coronal plane) were evaluated.

Figure 2 Position test of postural stability

3.3 Statistical analysis

The SPSS version 23.0 was used for statistical analysis. Spearman's rank correlation coefficient was used to determine a correlation of the lumbar stability level and postural sway in the coronal and sagittal plane. The level of statistical significance was set at $p<0.05$.

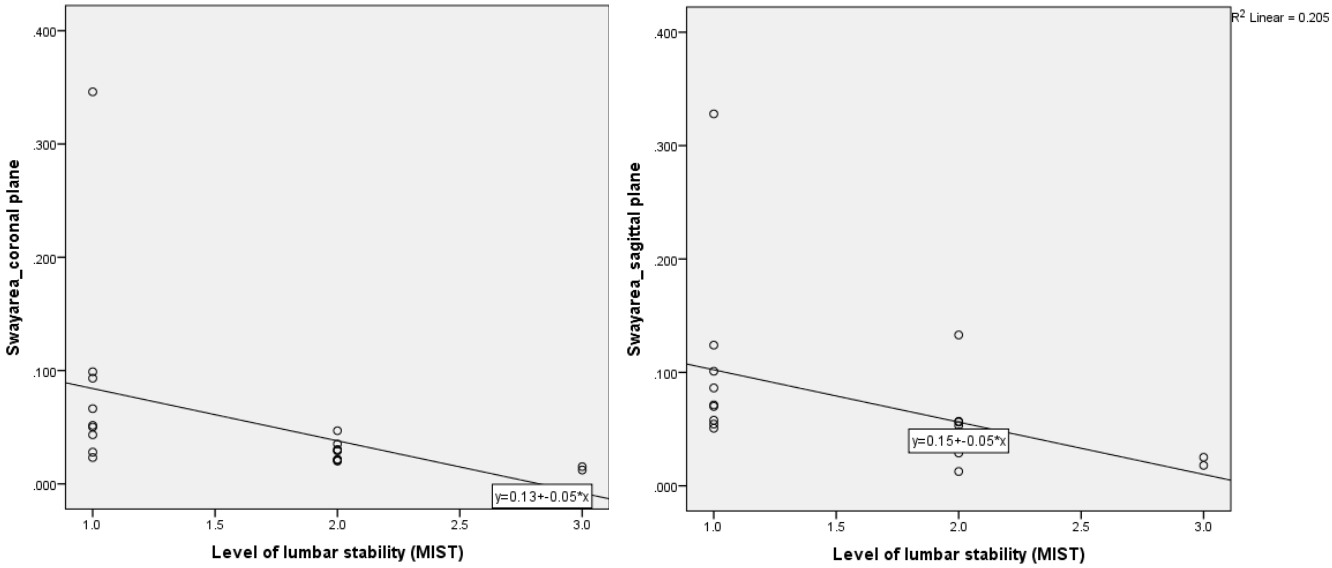
4. Results

Twenty participants whose ages ranged from 20 to 55 years were recruited in this study. The baseline characteristics demonstrated in Table 1.

Table 1 Baseline characteristics of the participants

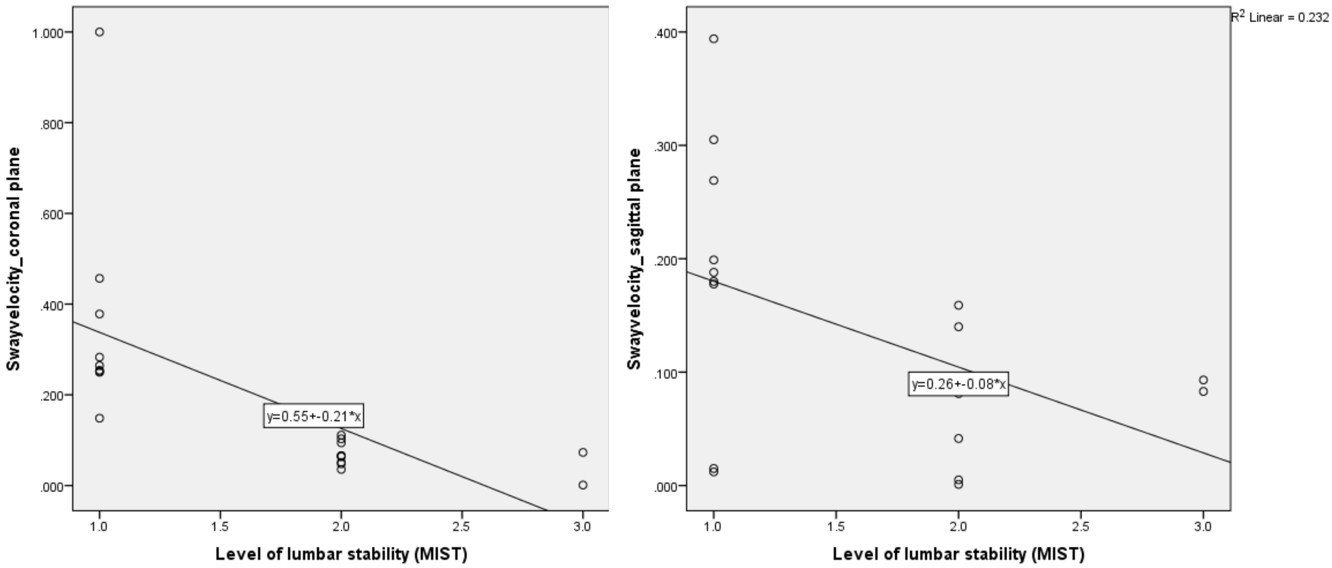
Parameters	
Age (years) Mean (SD)	38.21 (15.90)
Weight (kg) Mean (SD)	57.32 (10.20)
Height (cm) Mean (SD)	161.10 (5.10)
BMI (kg/m^2) Mean (SD)	20.42 (1.32)
MIST Median (Q1,Q3)	1 (1, 2)
Sway area in coronal plane Mean (SD)	0.54 (0.07)
Sway area in sagittal plane Mean (SD)	0.07 (0.07)
Sway velocity in coronal plane Mean (SD)	0.21 (0.13)
Sway velocity in sagittal plane Mean (SD)	0.13 (0.10)

The correlation between the lumbar stability level and postural stability was represented in the scatter plots. The results showed significant negative correlation between the level of MIST and sway area in both sagittal plane (r = -0.692, p < 0.05) and coronal plane (r = -0.740, p < 0.05) (Figure 3). In addition, the results found significant negative correlation between levels of lumbar stability and sway velocity in coronal and sagittal plane (r = -0.850, p < 0.05 and r = -0.608, p < 0.05 respectively) (Figure 4).



A B

Figure 3 Scatter plot between MIST levels and sway area (n=20), A = negative correlation between the level of MIST and sway area in coronal plane, B = negative correlation between the level of MIST and sway area in sagittal plane.



A B

Figure 4 Scatter plot between MIST levels and sway velocity (n=20), A = negative correlation between the level of MIST and sway velocity in coronal plane, B = negative correlation between the level of MIST and sway velocity in sagittal plane.

5. Discussion

This study found a significant negative correlation between the lumbar stability level and sway area in the coronal plane and sagittal plane (r = -0.740, p<0.05, r = -0.692, p<0.05 respectively). In addition, the result demonstrated a negative correlation between the lumbar stability level and sway velocity in the coronal plane and sagittal plane (r = -0.850, p<0.05, r = -0.608, p<0.05 respectively). The result from this study indicated that patients with high lumbar stability level were likely to low sway area and sway velocity in both anteroposterior (sagittal plane) and mediolateral (coronal plane). On the other hand, the patients who had poor lumbar stability demonstrated poor postural stability to control the body. This finding agrees with the previous study that found the patients with LBP were likely to affect postural control such as impairments of lumbar proprioception (Brumagne, Cordo, & Verschueren, 2004). Patients with chronic LBP have lumbopelvic dysfunction and impaired muscle activation causing poor postural control and pelvic stability (Radebold, Cholewicki, Panjabi, & Patel, 2000). Moreover, such patients lack the central nervous system control of locomotion (Janda, 1978). They had delayed feedforward activation of transversus abdominis muscle cause of decreasing lumbar stability. In LBP patients, core muscle strength and stabilizer muscles recruitment were reported to decrease the effect on lumbar stability (Bergmark, 1989; Costa et al., 2009; O'Sullivan, 2005; Panjabi, 1992). The core stabilizers contraction increases intra-abdominal pressure (IAP) while reducing the compression forces on the spine (Cresswell, Oddsson, & Thorstensson, 1994; Cresswell & Thorstensson, 1994). The transversus abdominis in patients with LBP was decreased function to maintain the IAP that affects spinal support (Richardson, Jull, Hides, & Hodges, 1999). Furthermore, impaired motor control of the trunk, as a result of LBP has been suggested to determine increased postural sway (Leinonen et al., 2003; Mazaheri, Coenen, Parnianpour, Kiers, & van Dieën, 2013; Radebold, Cholewicki, Polzhofer, & Greene, 2001). Radebold et al. (Radebold et al., 2001)found a correlation between poor balance control in an unstable sitting position and delayed trunk muscle contraction after a release perturbation in patients with LBP. The sway velocity has been demonstrated to sensitive of proprioception. A decrease in both the sway area and sway velocity represents an increased ability to perform an upright function (Palmieri et al., 2002). An increased value of sway variable suggests a decreased ability to maintain postural control. If the patients had high sway area and velocity, they had poor trunk control to neutral position and decreasing of lumbar stability.

The limitation of this study included a small sample size that is not general to all NCLBP population. Future study should evaluate using a larger sample size. This preliminary result should also be validated using a large sample size in the future. In addition, most of the participants had a low level of stability and not fully at all level. Therefore, the future study may include the participants with different performance.

6. Conclusion

The results of this study showed a significant negative correlation between the lumbar stability levels and the postural sway in both coronal plane and sagittal plane. Moreover, the results indicate that the participants with high lumbar stability level may lower the sway area and sway velocity. If the participants demonstrated low lumbar stability level or high sway, they would begin with the simple exercise positions. Therefore, the patients with low lumbar stability level should not begin the exercise using a high exercise level because an injury might occur. The MIST can use to predict the problems of sway in the patient with LBP. These findings can apply to design exercise programs for patients with NCLBP.

7. Acknowledgements

The authors are very grateful to all participants and faculty of physical therapy and sport medicine, Rangsit University, Thailand. The achievement of this research would not have been occurred without the support fund from Research Institute of Rangsit University.

8. References

Andersson, G. B. (1999). Epidemiological features of chronic low-back pain. *The lancet, 354*(9178), 581-585.

Bergmark, A. (1989). Stability of the lumbar spine: a study in mechanical engineering. *Acta Orthopaedica Scandinavica, 60*(sup230), 1-54.

Brumagne, S., Cordo, P., & Verschueren, S. (2004). Proprioceptive weighting changes in persons with low back pain and elderly persons during upright standing. *Neuroscience letters, 366*(1), 63-66.

Childs, J. D., Cleland, J. A., Elliott, J. M., Teyhen, D. S., Wainner, R. S., Whitman, J. M., . . . Delitto, A. (2008). Neck pain: clinical practice guidelines linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association. *Journal of Orthopaedic & Sports Physical Therapy, 38*(9), A1-A34.

Cho, K., Lee, K., Lee, B., Lee, H., & Lee, W. (2014). Relationship between postural sway and dynamic balance in stroke patients. *Journal of physical therapy science, 26*(12), 1989-1992.

Chou, R., Qaseem, A., Snow, V., Casey, D., Cross, J. T., Shekelle, P., & Owens, D. K. (2007). Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American Pain Society. *Annals of internal medicine, 147*(7), 478-491.

Costa, L. O., Maher, C. G., Latimer, J., Hodges, P. W., Herbert, R. D., Refshauge, K. M., . . . Jennings, M. D. (2009). Motor control exercise for chronic low back pain: a randomized placebo-controlled trial. *Physical therapy, 89*(12), 1275-1286.

Cresswell, A., Oddsson, L., & Thorstensson, A. (1994). The influence of sudden perturbations on trunk muscle activity and intra-abdominal pressure while standing. *Experimental brain research, 98*(2), 336-341.

Cresswell, A., & Thorstensson, A. (1994). Changes in intra-abdominal pressure, trunk muscle activation and force during isokinetic lifting and lowering. *European journal of applied physiology and occupational physiology, 68*(4), 315-321.

Gheldof, E. L., Vinck, J., Vlaeyen, J. W., Hidding, A., & Crombez, G. (2005). The differential role of pain, work characteristics and pain-related fear in explaining back pain and sick leave in occupational settings. *Pain, 113*(1-2), 71-81.

Guo, H.-R., Chang, Y.-C., Yeh, W.-Y., Chen, C.-W., & Guo, Y. L. (2004). Prevalence of musculoskeletal disorder among workers in Taiwan: a nationwide study. *Journal of occupational health, 46*(1), 26-36.

Hagins, M., Adler, K., Cash, M., Daugherty, J., & Mitrani, G. (1999). Effects of practice on the ability to perform lumbar stabilization exercises. *Journal of Orthopaedic & Sports Physical Therapy, 29*(9), 546-555.

Hodges, P. W. (2003). Core stability exercise in chronic low back pain. *Orthopedic Clinics, 34*(2), 245-254.

Janda, V. (1978). Muscles, central nervous motor regulation and back problems *The neurobiologic mechanisms in manipulative therapy* (pp. 27-41): Springer.

Keawduangdee, P., Puntumetakul, R., Boonprakob, Y., Wanpen, S., & Siritaratiwat, W. (2010). The prevalence of musculoskeletal disorders in the textile occupation in Khon Kaen Province. *Journal of medical technology and physical therapy, 22*(3), 292-301.

Leinonen, V., Kankaanpää, M., Luukkonen, M., Kansanen, M., Hänninen, O., Airaksinen, O., & Taimela, S. (2003). Lumbar paraspinal muscle function, perception of lumbar position, and postural control in disc herniation-related back pain. *Spine, 28*(8), 842-848.

Mazaheri, M., Coenen, P., Parnianpour, M., Kiers, H., & van Dieën, J. H. (2013). Low back pain and postural sway during quiet standing with and without sensory manipulation: a systematic review. *Gait & posture, 37*(1), 12-22.

Mok, N. W., Brauer, S. G., & Hodges, P. W. (2004). Hip strategy for balance control in quiet standing is reduced in people with low back pain. *Spine, 29*(6), E107-E112.

Nachemson, A. L., & Andersson, G. B. (1982). Classification of low-back pain. *Scandinavian journal of work, environment & health*, 134-136.

Nies, N., & Sinnott, P. L. (1991). Variations in balance and body sway in middle-aged adults. Subjects with healthy backs compared with subjects with low-back dysfunction. *Spine, 16*(3), 325-330.

O'sullivan, P. B., Phyty, G. D. M., Twomey, L. T., & Allison, G. T. (1997). Evaluation of specific stabilizing exercise in the treatment of chronic low back pain with radiologic diagnosis of spondylolysis or spondylolisthesis. *Spine, 22*(24), 2959-2967.

O'Sullivan, P. (2005). Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. *Manual therapy, 10*(4), 242-255.

Ogunbode, A. M., Adebusoye, L. A., & Alonge, T. O. (2013). Prevalence of low back pain and associated risk factors amongst adult patients presenting to a Nigerian family practice clinic, a hospital-based study. *African journal of primary health care & family medicine, 5*(1).

Palmieri, R. M., Ingersoll, C. D., Stone, M. B., & Krause, B. A. (2002). Center-of-pressure parameters used in the assessment of postural control. *Journal of Sport Rehabilitation, 11*(1), 51-66.

Panjabi, M. M. (1992). The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. *Journal of spinal disorders, 5*, 383-383.

Radebold, A., Cholewicki, J., Panjabi, M. M., & Patel, T. C. (2000). Muscle response pattern to sudden trunk loading in healthy individuals and in patients with chronic low back pain. *Spine, 25*(8), 947-954.

Radebold, A., Cholewicki, J., Polzhofer, G. K., & Greene, H. S. (2001). Impaired postural control of the lumbar spine is associated with delayed muscle response times in patients with chronic idiopathic low back pain. *Spine, 26*(7), 724-730.

Richardson, C., Jull, G., Hides, J., & Hodges, P. (1999). *Therapeutic exercise for spinal segmental stabilization in low back pain*: Churchill Livingstone London.

Van Tulder, M., Becker, A., Bekkering, T., Breen, A., Gil del Real, M. T., Hutchinson, A., . . . Malmivaara, A. (2006). Chapter 3 European guidelines for the management of acute nonspecific low back pain in primary care. *European spine journal, 15*, s169-s191.

Willardson, J. M. (2007). Core stability training: applications to sports conditioning programs. *The Journal of Strength & Conditioning Research, 21*(3), 979-985.

Wohlfahrt, D., Jull, G., & Richardson, C. (1993). The relationship between the dynamic and static function of abdominal muscles. *Australian Journal of Physiotherapy, 39*(1), 9-13.