The Effect of 8 Weeks of Dynamic Neuromuscular Stabilization Training on Pain, Electromyography Activity of Lumbar Muscles, and Quality of Life in People with Chronic Low Back Pain

Ahmed Mohammed Kadhim ALzuwaini, Reza Mahdavinejad*, Mohammed Challab Idan Almasoodi

Department of Sport Injuries and Corrective Exercises, Faculty of Sport Sciences, University of Isfahan, Isfahan Iran
Email: r.mahdavinejad@spr.ui.ac.ir

Abstract

Objectives: To evaluate the effects of an 8-week DNS training program on pain, EMG activity, and quality of life in individuals with CLBP. Design: Semi-experimental study. Participants: Thirty male participants with non-specific CLBP, divided into DNS (n=15) and control (n=15) groups. Main Outcome Measures: Pain levels (Quebec Back Pain Disability Scale), lumbar muscle EMG activity (MegaWin EMG device), and quality of life (SF-36 questionnaire). Results: The DNS group showed significant pain reduction (P=0.00), increased EMG activity in rectus abdominis (P=0.000), erector spinae (P=0.002), and gluteus maximus (P=0.002), and improved quality of life (P=0.02). Conclusions: DNS exercises significantly reduce pain, enhance muscle activity, and improve quality of life in CLBP patients

Keywords: Dynamic neuromuscular stabilization, chronic low back pain, electromyography, quality of life, rehabilitation.

1. Introduction

Context and Importance

Low back pain (LBP) is a prevalent condition affecting over 85% of individuals at some point in their lives and is a leading cause of disability. Although most people recover within two to six weeks, 10% to 15% require ongoing rehabilitation. LBP significantly impacts social, economic, and health sectors, particularly in professions such as surgeons (9%), nurses (84%), and pregnant women (62%) (Gordon et al., 2016).

Literature Review

Muscle imbalance is a critical factor in 90% of nonspecific chronic LBP cases, which lack a specific pathological cause and affect the area from the lower chest to the pelvis (Furlan et al., 2009). People with repetitive daily activities and no regular sports involvement are more prone to LBP (Bandi, 1994). Pain, a primary symptom, limits activity by increasing lumbar lordosis, compressing nerve roots, and weakening core muscles (Park et al., 2023). Effective treatments often involve strength and stretching exercises to improve muscle function and stability (Gordon et al., 2016). Recent studies highlight the potential of dynamic neuromuscular stabilization (DNS) training in enhancing spinal stability and reducing pain (Ghavipanje et al., 2022; Yon, 2017).

Study Rationale

Despite the promise shown by DNS training, limited studies have investigated its effects on nonspecific chronic LBP. There are still many questions about DNS exercises' specific benefits and mechanisms for this type of back pain. Therefore, this study seeks to fill this gap by providing empirical evidence on the effectiveness of DNS training in improving clinical outcomes for individuals with chronic LBP.

Objective

This study aims to evaluate the impact of an 8-week dynamic neuromuscular stabilization exercise program on pain levels, electromyographic activity of lumbar muscles, and quality of life in men with nonspecific chronic LBP. The hypothesis is that DNS training will significantly reduce pain, enhance muscle activity, and improve the quality of life of the study participants.

2. Research Methodology

Study Design

This study employed a semi-experimental design to evaluate the effects of dynamic neuromuscular stabilization (DNS) training on pain levels, electromyographic (E.M.G.) activity of lumbar muscles, and quality of life in men with nonspecific chronic low back pain (CLBP).

Participants

Thirty male participants with nonspecific CLBP were recruited and randomly assigned to the DNS exercise group (n=15) or the control group (n=15). The inclusion criteria were:

- Consent to participate in the study.
- Presence of CLBP symptoms for at least three months.
- No history of spine or lower limb surgery, severe injury, or therapeutic interventions (e.g., physiotherapy) in the last six months.

The exclusion criteria were:

- Severe vertebral spine injury history.
- Non-participation in more than five exercise sessions.
- Withdrawal of consent or non-participation in post-test evaluations.

Intervention

The experimental group performed DNS exercises thrice weekly for eight weeks, lasting 45-60 minutes each session. The training protocol included a warm-up phase, main DNS exercises (divided into three levels: superficial, medium, and advanced), and a cool-down phase. Exercises were supervised and adjusted based on participants' performance.

Outcome Measures

1. Pain Level: Assessed using the Quebec Back Pain Disability Scale, which contains 25 questions with scores ranging from 0 (no pain) to 100 (severe pain).
2. Electromyographic Activity: Measured using an 8-channel MegaWin E.M.G. device to assess the activity levels of the rectus stomach, erector spine, and gluteus maximus muscles. E.M.G. data were processed using MegaWin software.
3. Quality of Life: Evaluated using the SF-36 questionnaire, which measures physical and mental health across various domains.

Data Collection

Pre-test assessments were conducted before the intervention, and post-test assessments were performed after the eight-week training period. The data collection process included:

1. E.M.G. tests for lumbar muscle activity.
2. Quebec Back Pain Disability Scale for pain assessment.
3. SF-36 questionnaire for quality-of-life evaluation.

Statistical Analysis

Data were analyzed using repeated measures ANOVA to determine the effects of the DNS training program on the measured outcomes. The significance level was set at 0.05. SPSS version 26 software was used for statistical analysis.

By systematically evaluating the impact of DNS exercises, this study aims to povide comprehensive insights into their effectiveness in managing nonspecific chronic low back pain.

3. Pain Measurement

The level of low back pain (LBP) in patients was evaluated using the Quebec Back Pain Disability Scale. This questionnaire includes 25 questions, each with five options. The first option is valued at zero, indicating no pain, while the remaining options score pain intensity on a scale from 0 to 100. A score of 0 denotes complete health and no pain, 25 indicates moderate pain, and scores of 50, 75, and 100 correspond to high, very high, and acute pain, respectively. The Quebec questionnaire has been validated and has 84% reliability in measuring LBP (Speksnijder et al., 2014).

Electromyographic Activity of Back Muscles

Electromyographic (E.M.G.) activity of the back muscles was measured using the MegaWin 8-channel surface electromyography device. To prepare for electrode placement, hair and fine hairs were removed from the skin using special disposable razors, and the skin was exfoliated with soft sandpaper. After cleaning the skin with 5% isopropyl alcohol, electrodes were attached according to the European SENIAM protocol.

1 Electrode Placement:

- Spinal Extensor Muscles: Electrodes were placed at three levels: L3 (3 cm from the spinous appendage), T9 (5 cm from the spinous appendage), and C4 (2 cm from the spinous appendage), using AgCl and wet Ag sensor gel leads, spaced 2 cm apart.

- Rectus Abdominis Muscle: Electrodes were placed on the middle part of the muscle ventricle.

- Gluteus Maximus Muscle: Electrodes were placed on the muscle ventricle while the subject performed hip extension.

2 Procedure:

- Maximum voluntary (isometric) contraction (MVC) was measured by taking the maximum contraction for 6 seconds, repeated after 2 minutes of rest. The main movement involved 10 seconds of flexi-bar oscillation with the right hand at a 90-degree shoulder abduction.

- Three repetitions of the movement were performed in three weight-bearing positions: same side, opposite side, and both legs, totalling nine repetitions with 1-minute rest between each.

- MVC for spinal erector muscles was calculated at L3 and T9 levels using the Bearing Sorenson position and at the C4 level with resistance in a sitting position.

3 Signal Processing:

- E.M.G. signals were recorded at a bandwidth of 10 to 500 Hz and a sampling frequency of 1000 Hz.

- MegaWin ver. Two software applications were used for signal processing and AEMG calculation.

- R.M.S. data were obtained from raw E.M.G. signals and normalized by dividing the activity of each muscle by its MVC, multiplied by 100.

Quality of Life

The quality of life was assessed using the SF-36 questionnaire, which includes 36 questions covering physical and mental health dimensions (Prat-Luri et al., 2023).

Training Protocol for Dynamic Neuromuscular Stability Exercises (DNS)

The DNS group performed the exercise protocol for eight weeks, with three sessions per week, each lasting 45-60 minutes. Sessions included a warm-up phase with brisk walking, gentle running, and stretching, followed by DNS exercises designed in three levels: superficial, medium, and advanced. Exercises were progressively increased in intensity based on correct implementation and training pressure from previous sessions. The control group continued their usual daily activities without any special exercises. (Son et al., 2017; Qavi Panjeh et al., 2022).

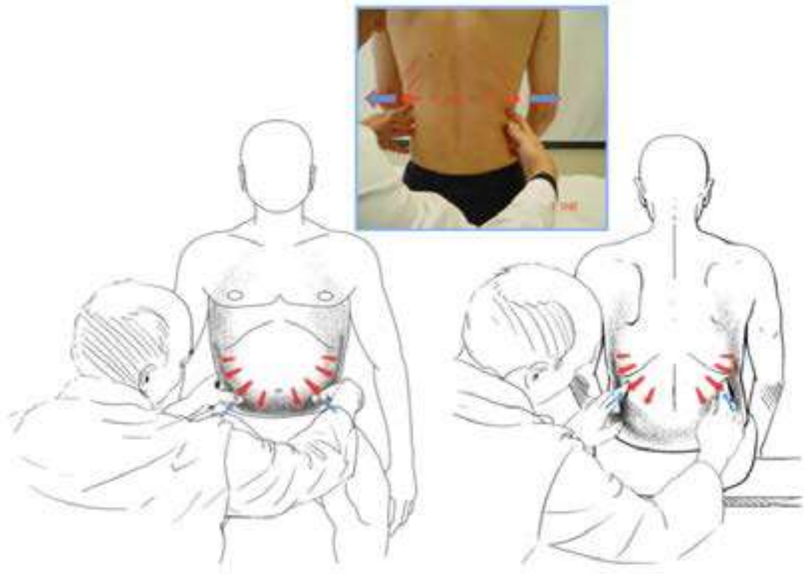

Figure 1 Diaphragm test

Conduct a respiratory and postural assessment. Assessment from behind.(Alena kobesova 2014)

Table 1 Dynamic neuromuscular stability training protocol (DNS)

Practice								
Diaphragmatic breathing	3 x 10 repetition	3 x 12 repetition	3 x 15 repetition	3 x 18 repetition	3 x 20 repetition	3 x 23 repetition	3 x 25 repetition	3 x 30 repetition
Crunch	3 x 10 repetition	3 x 12 repetition	3 x 15 repetition	3 x 18 repetition	3 x 20 repetition	3 x 23 repetition	3 x 25 repetition	3 x 30 repetition
Crunch with an	3 x 10 repetition	3 x 12 repetition	3 x 15 repetition	3 x 18 repetition	3 x 20 repetition	3 x 23 repetition edition	3 x 25 repetition	3 x 30 repetition

outstretched leg								
Trunk rotation in crunch position	3 x 10 repetition	3 x 12 repetition	3 x 15 repetition	3 x 18 repetition	3 x 20 repetition	3 x 23 repetition	3 x 25 repetition	3 x 30 repetition
Sitting obliquely	3 x 10 repetition	3 x 12 repetition	3 x 15 repetition	3 x 18 repetition	3 x 20 repetition	3 x 23 repetition	3 x 25 repetition	3 x 30 repetition
Lying on the stomach	3 x 10 repetition	3 x 12 repetition	3 x 15 repetition	3 x 18 repetition	3 x 20 repetition	3 x 23 repetition	3 x 25 repetition	3 x 30 repetition
Side plank	3 x 10 repetition	3 x 12 repetition	3 x 15 repetition	3 x 18 repetition	repetition	3 x 23 repetition	3 x 25 repetition	3 x 30 repetition
All fours with knees raised from the ground (bear position)	3 x 10 repetition	3 x 12 repetition	3 x 15 repetition	3 x 18 repetition	3 x 20 repetition	3 x 23 repetition	3 x 25 repetition	3 x 30 repetition

4. Results

Descriptive information related to the research subjects (age, height and weight)

Table 2 Mean and Standard Derivation of the descriptive information of the subject

Variables	DNS Training Group (n=15)	Control Group (n=15)	P
	Mean ± s d	Mean ± s d	
Age (years)	53.7.± 4.19	54.2±1.17	0.4
Height (cm)	167.9±2.24	169.4±2.24	0.8
Weight (kg)	63.9±2.94	66.6±2.27	0.14

Table 3 shows the Shapiro-Wilk test results, confirming normal data distribution. Thus, parametric tests, including repeated measures ANOVA, were used for analysis.

Table 3 Shapiro-Wilk test results to check the normality of data distribution

Test		Group	sig	
			Pre-test	post-test
The pain		experimental	0.18	**0.9**
		Control	0.31	**0.12**
Quality of Life		experimental	0.28	**0.19**
		Control	0.39	**0.21**
Electromyography of muscles (mV)	Rectus abdominis	experimental	0.12	**0.65**
		Control	0.28	**0.93**
	Gluteus Maximus	experimental	0.32	**0.23**
		Control	0.78	**0.42**
	Erector Spine	experimental	**0.22**	**0.2**
		Control	**0.71**	**0.1**

The repeated measures analysis of variance (ANOVA) indicated significant intragroup, intergroup, and interactive effects on pain levels, electromyographic activity of back muscles, and quality of life after eight weeks of dynamic neuromuscular stability training ($p < 0.05$).

Table 4 Descriptive information and analysis of variance test with repeated measures of research variables

Variable		Test Period	Experimental (15)	Control (15)	Within Group Comparison	Between Group Comparison	Interaction
pain (score)		Pre-test	51.1±1.1	48.1±4.1	F=13.01	F=18.05	F=19.02
		post-test	39.9±3.6	47.9±4.2	P=0.02	P=0.001	P=0.000
Electromyography of muscles (mV	Rectus abdominis	Pre-test	0.3±0.01	0.4±0.02	F=16.2	F=10.04	F=39.01
		post-test	0.7±0.02	0.5±0.03	P=0.001	P=0.003	P=0.000
	gluteus maximus	Pre-test	0.2±0.09	0.3±0.09	F=67.3	F=43.2	F=56.01
		post-test	0.6±0.03	0.2±0.03	P=0.01	P=0.03	P=0.002
	erector Spine	Pre-test	0.4±0.03	0.4±0.001	F=6.05	F=9.5	F=18.1
		post-test	0.9±0.06	0.4±0.02	P=0.02	P=0.03	P=0.03
Quality of Life		Pre-test	66.1±2.1	64.6±3.5	F=33.05	F=51.05	F=21.01
		post-test	81.9±2.6	63.8±2.1	P=0.01	P=0.001	P=0.001

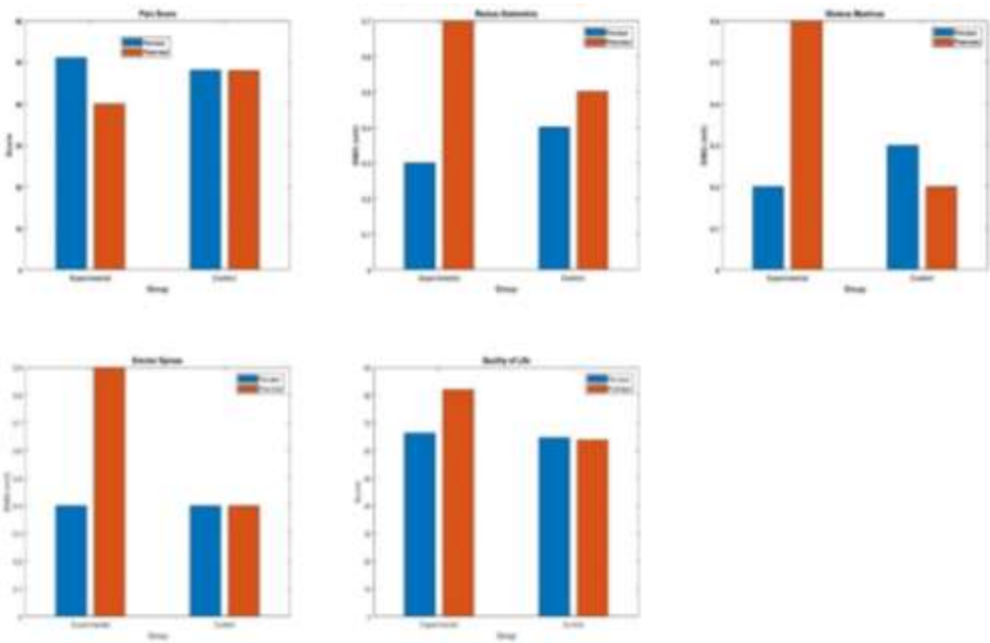

Figure 2 Comparison of Experimental and Control Groups

5. Discussion

This research demonstrated a significant reduction in pain levels among men with nonspecific chronic low back pain (CLBP) following an 8-week dynamic neuromuscular stabilization (DNS) training program. These findings align with the study by (Hayden et al., 2005), which concluded that individually tailored exercise treatments designed and supervised by physiotherapists effectively reduce chronic low back pain when combined with strengthening or stretching exercises as needed.

(Arsanjo et al. 2022) They reviewed the effects of proprioceptive neuromuscular facilitation (PNF) exercises on pain and disability in individuals with chronic low back pain. They compared PNF with control groups, core strengthening exercises, and conventional physical therapy, concluding that PNF exercises reduce pain and improve disability. Although the evidence quality was moderate, this supports using abdominal muscle strength training in preventing and rehabilitating low back pain.

(Quentin et al. 2021) highlighted the benefits of home exercise training in reducing pain intensity and functional limitations in people with nonspecific low back pain. The DNS training protocol in our study aimed to restore spinal stability and regulate intra-abdominal pressure, reducing the demand on posterior extensor muscles and the compressive force on the lumbar spine. DNS exercises effectively improved lumbar stability by enhancing neuromuscular stability and reducing pressure on the discs and vertebrae.

Various muscles play roles in maintaining lumbar vertebrae stability, including pelvic and local muscles. Segmental instability often arises from dysfunction in local stabilizing muscles, reducing their activity, stiffness, and tonicity. Pain exacerbates this by diminishing the muscles' stabilizing role, prompting the core nervous system to increase surface muscle activity. DNS exercises enhance the activity of local stabilizing muscles, improving their performance and reducing the false stability created by surface muscle stiffness. This leads to improved movement patterns, increased segmental stability, and better control of the neutral zone, allowing greater lumbar spine mobility.

(Falla et al.2004) emphasized the importance of neurological studies in understanding balance and spinal stabilization. Their findings underscored the role of postural feedforward responses, controlled by the core nervous system, in maintaining lumbar stability during activity. Dysfunction in these responses, particularly in the multifidus and transversus abdominis muscles, increases postural instability and back pain. Our study supports these findings, demonstrating that DNS exercises improve muscle activity and spinal stability.

(Garwah et al. 2015) noted that chronic nonspecific low back pain patients often experience contraction in spinal and abdominal extensor muscles, leading to reduced spinal stability. DNS exercises enhance muscle activity, creating stiffness and increasing spinal load, which improves stability. Our results showed significant improvements in E.M.G. activity of the back muscles after eight weeks of DNS training.

Additionally, DNS exercises significantly improved quality of life (QoL), as evidenced by increased scores across all QoL subscales. This contrasts with (Claiborne et al., 2002), who found no significant psychological benefits. Our study aligns with (Horang et al., 2005), who highlighted that functional status and psychological factors are more influential on health-related QoL than physical damage alone. DNS exercises improved physical and mental health, leading to better overall QoL.

Improvements in QoL may be attributed to reduced pain, increased daily activity functionality, and decreased disability risk due to healthier body mechanics. DNS exercises aim to restore participants to optimal performance levels, significantly reducing disability risk and enhancing performance. Additionally, integrating psychosocial self-help skills and stress management recommendations within the DNS program likely contributed to improved psychological status.

However, the study's limitations include its all-male sample, which may limit generalizability. Future research should consider a more diverse sample to enhance applicability. DNS exercises focus on core muscle control, balance, correct posture, spinal stability, and proper daily movement execution. These exercises improve neuromuscular coordination and prevent joint and muscle damage, aligning with correct body biomechanics.

6. Conclusion

This research showed that performing DNS exercises for patients with low back pain significantly decreases pain and improves quality of life. Additionally, there is a significant increase in muscle electromyography activity and quality of life. DNS exercises will likely achieve these benefits by enhancing flexibility, endurance, strength, stability, neuromuscular control, coordination, movement control, and correct diaphragmatic breathing patterns. These improvements help relieve muscle tension, reduce pain, and increase activity levels in patients with low back pain.

WORKS CITED

Arcanjo, F. L., Martins, J. V. P., Moté, P., Leporace, G., de Oliveira, D. A., de Sousa, C. S., ... & Gomes-Neto, M. (2022). Proprioceptive neuromuscular facilitation training reduces pain and disability in individuals with chronic low back pain: A systematic review and meta-analysis—Complementary Therapies in Clinical Practice, 46, 101505.

Bandy WD, Irion JM, Briggler M. The Effect of time and frequency of static stretching on flexibility of the hamstring muscles. Phys Ther. 1997 Oct;77(10):1090-6.

Bagg, M. K., Wand, B. M., Cashin, A. G., Lee, H., Hübscher, M., Stanton, T. R., ... & McAuley, J. H. (2022). Effect of graded sensorimotor retraining on pain intensity in patients with chronic low back pain: A randomized clinical trial. JAMA, 328(5), 430-439.

Carcia, C. R., & Martin, R. L. (2007). The influence of gender on gluteus medius activity during a drop jump. Physical Therapy in Sport, 8(4), 169-176.

Falla, D.; Rainoldi, A.; Merletti, R.; Jull, G. (2004). "Spatio-temporal evaluation of neck muscle activation during postural perturbations in healthy subjects". Journal of Electromyography and Kinesiology, 14(4), 463-474

Frank, C., A. Kobesova, and P. Kolar, Dynamic neuromuscular stabilization & sports rehabilitation. International journal of sports physical therapy, 2013. 8(1):.62-73

Frizziero, A., Pellizzon, G., Vittadini, F., Bigliardi, D., & Costantino, C. (2021). Efficacy of core stability in nonspecific chronic low back pain. Journal of functional morphology and kinesiology, 6(2), 37.

Furlan, A. D., Imamura, M., Dryden, T., & Irvin, E. (2009). Massage for low back pain: an updated systematic review within the Cochrane Back Review Group framework. Spine, 34(16), 1669–1684.

Ghavipanje, V., Rahimi, N. M., & Akhlaghi, F. (2022). Six Weeks Effects of Dynamic Neuromuscular Stabilization (DNS) Training in Obese Postpartum Women with Low Back Pain: A Randomized Controlled Trial. Biological research for nursing, 24(1), 106-114.

Gordon, R., & Bloxham, S. (2016). A Systematic Review of the Effects of Exercise and Physical Activity on Nonspecific Chronic Low Back Pain. Healthcare (Basel, Switzerland), 4(2), 22–29-.

Park, M. W., Park, S. J., & Chung, S. G. (2023). Relationships Between Skeletal Muscle Mass, Lumbar Lordosis, and Chronic Low Back Pain in the Elderly. Neurospine, 20(3), 959-968.

Hatfield, G. (2009). The effects of quadriceps impairment on lower limb kinematics, kinetics and muscle activation during gait in young adults (Doctoral dissertation, Dalhousie University).

Hayden, J., Van Tulder, M. W., Malmivaara, A., & Koes, B. W. (2005). Exercise therapy for treatment of nonspecific low back pain. Cochrane database of systematic reviews, ; (3):858-1465.

Hodges, P. W., & Danneels, L. (2019). Changes in structure and function of the back muscles in low back pain: different time points, observations, and mechanisms. Journal of orthopaedic & sports physical therapy, 49(6), 464-476.

Khauv KB, John C. Health-related Quality of Life Improvement in Adult Patients with Chronic Low Back Pain under Low- Force Chiropractic Care: A Practice-Based Study. Chiropractic Journal of Australia. 2011; 41(4): 118-122.

Maroufi N, Ahmadi A, Mousavi Khatir SR. A comparative investigation of flexion relaxation phenomenon in healthy and chronic neck pain subjects. Eur Spine J. 2013 Jan;22(1):162-8

Prat-Luri, A., de Los Rios-Calonge, J., Moreno-Navarro, P., Manresa-Rocamora, A., Vera-Garcia, F. J., & Barbado, D. (2023). Effect of trunk-focused exercises on pain, disability, quality of life, and trunk physical fitness in low back pain and how potential effect modifiers modulate their effects: A systematic review with meta-analyses. Journal of Orthopaedic & Sports Physical Therapy, 53(2), 64-93.

Quentin, C., Bagheri, R., Ugbolue, U. C., Coudeyre, E., Pelissier, C., Descatha, A., ... & Dutheil, F. (2021). Effect of home exercise training in patients with nonspecific low back pain: a systematic review and Meta-analysis. International Journal of Environmental Research and Public Health, 18(16), 8430.

Speksnijder CM, Koppenaal T, Knottnerus JA, Spigt M, Staal JB, Terwee CB. Measurement Properties of the Quebec Back Pain Disability Scale in Patients With Nonspecific Low Back Pain: Systematic Review. Phys Ther. 2016 Nov;96(11):1816-1831. doi: 10.2522/ptj.20140478. Epub 2016 May 26. PMID: 27231271

Son, M. S., Jung, D. H., You, J. S. H., Yi, C. H., Jeon, H. S., & Cha, Y. J. (2017). Effects of dynamic neuromuscular stabilization on diaphragm movement, postural control, balance and gait performance in cerebral palsy. NeuroRehabilitation, 41(4), 739–746.

Yoon, H.S. and J.S.H. You, Reflex-mediated dynamic neuromuscular stabilization in stroke patients: E.M.G. processing and ultrasound imaging. Technology and Health Care, (Preprint): p. 1-8.2017

Kobesova, A., Nørgaard, I., & Kolar, P. (2014). Dynamic Neuromuscular Stabilization. Department of Rehabilitation and Sports Medicine, 2nd Faculty of Medicine, Charles University, University Hospital Motol, Prague, Czech Republic; Private practice, London, United Kingdom. Retrieved from http://www.rehabps.com