POSSIBILITIES OF INFLUENCING THE FUNCTION OF THE DEEP STABILIZATION SYSTEM BY EXERCISING FOR LOW BACK PAIN

Elena Žiaková[1], Nina Sládeková[2], Jana Havlová[1]

[1]Department of Physiotherapy, Faculty of Nursing and Professional Health Studies, Slovak Medical University in Bratislava, Bratislava, Slovak Republic

[2]Faculty of Health Sciences, University of Ss. Cyril and Methodius in Trnava, Trnava, Slovak Republic

SUMMARY

Objectives: Chronic back pain is the most common cause of incapacity for work. The purpose of the study was to determine the effectiveness for activating the function of the deep stabilization system (DSS) in patients with chronic low back pain.

Methods: The effectiveness of three different methods was compared: Pilates method (PM), dynamic neuromuscular stabilization and balance aids on deep stabilization system function and pain perception in the lumbar spine. The group consisted of 75 patients.

Results: The results show differences in the effectiveness of the methods depending on the observed characteristics. The least significant differences were observed when comparing the Pilates method to balance aids. No statistically significant difference was observed in four out of five areas. The only area where a statistically significant effect of the exercise method got recorded was the intra-abdominal pressure test ($p < 0.05$). The lowest change was recorded in the measured values using the intra-abdominal pressure test at PM, and the highest change was recorded in Thomayer's values at dynamic neuromuscular stabilization.

Conclusion: By comparing the three methods it was noted that each of them has its own positive reaction to the pain and the muscular apparatus. The most appropriate method to affect DSS function appears the dynamic neuromuscular stabilization (DNS) concept, where was the most significant improvement in DSS activation and the most significant reduction in chronic low back pain.

Key words: low back pain, deep stabilization system, Pilates method, dynamic neuromuscular stabilization, balance aids

Address for correspondence: N. Sládeková, Faculty of Health Sciences, University of Ss. Cyril and Methodius in Trnava, Rázusova 14, 921 01 Piešťany, Trnava, Slovak Republic. E-mail: nina.sladekova@ucm.sk

https://doi.org/10.21101/cejph.a8199

INTRODUCTION

Chronic back pain troubles people of all ages and occurs in different situations. In clinical practice, we often encounter the diagnosis of vertebrogenic algic syndrome (VAS) in various sections of the spine and of various aetiology. The dominant symptom is pain in some part of the spine or pain radiating from the spine to other parts of the body (1). Pain can be divided in the lumbar region based on the so-called diagnostic triad: simple back pain, root (neurogenic) pain and pain caused by a serious spinal disease (2). There are three basic types of pain in the lumbar spine. Namely local pain (lumbago) at the site of the lesion, transferred pain (reflex) going from the spine to the limbs (pseudoradicular) or vice versa from visceral areas to the spine (viscerosomatic) and radicular pain of varying intensity indicated manoeuvres with radiation from the spine to the limbs with precise projection (3).

Deep stabilization system (DSS) is formed by the muscles that are in the deep layers of the muscle corset, tighter around the spine, in the abdominal area and in the lower abdomen. The base of the correct posture is the balance of deep and superficial muscles. In most people, the pelvis tilts too far backwards, which causes hyperlordosis. For a balanced body posture, which prevents problems with the spine, not only the abdominal muscles are important, but also the activity of the deep muscles in the back and pelvic floor (4, 5).

Pilates method (PM) is a set of 34 basic exercises which engage both muscle systems, the deep and the superficial, not only individual groups or segments. It improves stability, coordination, mobility, and flexibility of the spine (6, 7). The key point to the method is to control the muscles of the central girdle and to achieve a functional synergy of deep-seated muscles. It is based on the principle of control, consistent breathing, smooth movement, concentration, and stability. It balances the activity of agonists and antagonists (8). It uses lateral breathing, which helps to engage the abdominal contraction during the execution of the exercises, thereby keeping the deep muscles stable (9). It is very important that the pelvis and the head are in a neutral position, which automatically results in a natural extension of the spinal curves. This is achieved by proper adjustment and connection with lateral breathing (10).

By means of dynamic neuromuscular stabilization (DNS) techniques according to Kolář et al., the function of the muscle is affected in its postural and locomotion function. This function is automatic and in most people it has very limited volitional

control, not to mention the deep muscles, which are particularly important for postural (stabilizing, strengthening) function (5). The DNS concept is initially difficult to implement, and most of the patients are not able to hold the correct position and perform the exercise without manual correction by a physiotherapist in the initial phase.

The balance aids (BA), MTS Therapy Steps, Exertools DynaDisc Balance Cushion, Chango R4 Balance Boards etc., develop muscle coordination, remove muscle imbalances, support awareness of body position and serve to diversify and improve the quality of power exercise (11). By using BA, we increase the activity of the deep stabilization system as the basis for the coordinated movements that are performed with maximum efficiency and minimal energy expenditure. It is practiced slowly, by using and improving proper breathing techniques and concentration with the involvement of the central nervous system (11). With the dynamic aids, we "force" the patient to move, or to activate the muscles to keep them in the given position.

MATERIALS AND METHODS

Design

The purpose of the observational study was to compare the effect of three different therapies on chronic pain in the lumbar spine, due to muscle imbalance. We compared the effect of PM, DNS, and BA on DSS function, pain perception, and spinal range of motion.

Participants

The group consisted of 75 patients with chronic lumbar spine pain (low back pain) due to muscle imbalance. The selection process was based on patients with a diagnosis, according to the International Classification of Diseases, vertebrogenic algic syndrome in the lumbar area M 54.96 or vertebrogenic algic syndrome in the lumbosacral area M 54.97 (M54.96 dorsalgia, unspecified, lumbar area M54.97 dorsalgia, unspecified, lumbosacral area). All patients were examined and underwent rehabilitation in an outpatient medical facility as indicated by a doctor. The group consisted of people from the productive age range from 21 to 52 years, of both genders, and mostly with a sedentary type of job and one-sided workload. The criterion for the selection of patients was the predominance of lower back pain (lumbar and lumbosacral area of the spine), in which a certain radical treatment procedure (spray treatment) was not indicated, which could distort the results of the study. The patients signed an informed consent form saying they will be included in the clinical study during the treatment, while the conditions for respect and protection of work with personal data were met.

Criteria for not including patients in the group were acute pain, specific back pain, patients treated by antidepressants, patients with acute radicular symptomatology, patients with oncological diseases of the skeleton, inflammatory diseases of the spine, organic diseases of internal organs, scoliosis, rheumatological diseases, spondylolisthesis, and facet syndrome.

The patients were divided into 3 small groups of 25 people, while each group underwent the exercises using a different method. In the first group were applied the exercises according to Pilates (Pilates group), in the second we used dynamic neuromuscular stabilization according to P. Kolář (DNS group), and the last group exercised using balance aids (group with aids); 13 (52%) men and 12 (48%) women participated in Pilates exercises and exercises with the balance aids, with almost the same number of people in all age groups (20–29 years, 30–39 years and over 40 years). The group with DNS consisted of 15 men and 10 women. The study was conducted in accordance with ethical principles, based on the Helsinki Declaration of Medical Research on Human Subjects (12).

Intervention

Each patient underwent pre and post therapy assessment of subjective pain perception according to the numerical pain scale (13) and objective examination.

Tests for spine range of motion:

- Thomayer's test: (distance dactylion – pad);
- Stibor's test: development of the thoracic and lumbar spine (distance between C7 and S1 during leaning forward – 8–11 cm);
- Schober's test: development of the lumbar spine (difference in L5 distances – 10 cm cranially during leaning forward – at least 4 cm).

Assessment of intra-abdominal pressure using a diaphragm test (14).

To test the activity of intra-abdominal pressure and thus the involvement of the DSS, the Kolář diaphragm test was used with the following scale:

0 – the patient failed to activate the DSS function;

1 – the patient activated the DSS function with his feet on the ground/fitball;

2 – the patient activated the DSS function with the legs in triflexion;

3 – the patient activated the DSS function and held it even during exhalation (5).

Statistical Analysis

Microsoft Office Excel 2007 and the program "Statistical Package for the Social Sciences" were used for statistics, processing of measured values, creation of the tables and the graph. The results are processed by averaging, standard deviations, modus and median and are expressed as a percentage. To determine the statistical significance of the effect of different methodologies we used the Kruskal-Wallis test, and also Mann-Whitney U test was used as statistical method.

RESULTS

Apart from demographic data the patients also answered in the questionnaire whether they had problems with their spine in the past and whether they had been involved in regular therapy. The first question was answered positively by all respondents in all groups, all respondents had back problems in the past. In the DNS and balance aids groups, most of the patients (96% and 92%, respectively) attended therapy regularly, and in the Pilates group it was 64%.

Pilates Method

Patients participated in pretests and post-tests and regular exercise during the entire course of therapy using the Pilates. In 2 patients, there was no change after the output measurements of Thomayer's distances, Schober's and Stibor's distances. All the patients reported a reduction of the pain. When testing intra-abdominal pressure as an indicator of the engagement of the deep stabilization system, we noticed an improvement (Table 1). As a result of regular PM exercise, all tested patients improved their condition.

Dynamic Neuromuscular Stabilization

There were positive changes recorded in all monitored parameters in all 25 patients. The subjective perception of the pain in the lumbar area of the spine was significantly decreased, and greater changes can be also observed in the Thomayer's, Schober's and Stibor's distances. As a result of regular DNS exercise, all 25 patients in the questionnaire confirmed an improvement in their health status, a reduction of pain in the lumbar area, an increase in the back mobility, and a better muscle balance (Table 2).

Balance Aids

There was no change in Thomayer's distance and Schober's distance in 4 patients after the exercise, in Stibor's distance it was 3 patients. By testing intra-abdominal pressure, as an indicator for using of DSS, 21 patients recorded the improvement. Subjective perception of the pain was decreased, and improvement in taken test of the DSS. By the influence of regular exercise on BA, the improvement of the condition was noted in all tested patients, what is also confirmed by the values of measured results and the filled-out questionnaire after the therapy. All patients from the given group responded positively regarding their health status and they perceived a subjective reduction of the pain in the lumbar area and better muscle balance (Table 3).

Comparison of Methods

The most effective method is the DNS where improvements were noted in four observed parameters. The dynamic abilities of the spine were improved, the DSS function was activated, and the chronic pain was alleviated or eliminated. The second in order was an exercise designed for activating the function of

Table 1. *Average input and output values measured in Pilates method*

	Input value	Output value	Absolute value of the mean of differences	Standard deviation	Mode	Median
Thomayer (cm)	9.30	6.96	2.34	1.56	2	2
Schober (cm)	4.36	5.64	1.28	1.15	0.5	1
Stibor (cm)	5.82	7.22	1.40	1.20	2	1.5
Pain scale (points 0–10)	3.84	1.80	2.04	1.45	2	2
Intra-abdominal pressure (points 0–3)	0.40	1.20	0.80	0.91	1	1

Table 2. *Measurement values – dynamic neuromuscular stabilization*

	Input value	Output value	Absolute value of the mean of differences	Standard deviation	Mode	Median
Thomayer (cm)	14.80	11.18	3.62	1.94	2	3.5
Schober (cm)	2.20	4.10	1.90	1.40	2	2
Stibor (cm)	4.28	6.78	2.50	1.61	3	2.5
Pain scale (points 0–10)	5.40	2.88	2.52	1.61	3	3
Intra-abdominal pressure (points 0–3)	0.24	2.00	1.76	1.35	2	2

Table 3. *Measurement values – balance aids*

	Input value	Output value	Absolute value of the mean of differences	Standard deviation	Mode	Median
Thomayer (cm)	11.40	8.54	2.86	1.72	3	3
Schober (cm)	3.04	4.26	1.22	1.12	0.5	1
Stibor (cm)	5.26	6.80	1.54	1.26	1	1.5
Pain scale (points 0–10)	4.52	2.44	2.08	1.47	2	2
Intra-abdominal pressure (points 0–3)	0.48	2.00	1.52	1.25	2	2

DSS and eliminating the pain by BA. There was an improvement in all monitored parameters, reduction of the pain and thus also an improvement in the mobility of the spine. Third in order was proved PM. The mobility of the spine was improved, the subjective perception of the pain was decreased and the DSS function was activated in most of the patients. The changes in individual methodologies according to monitored parameters are listed in Table 4.

Table 5 shows the result of the Kruskal-Wallis test for all five monitored parameters. It can be asserted, at least with 95% confidence, that the applied methodologies have achieved different results from each other in all five indicators.

To find out where exactly the differences are, we compared individual pairs of the exercise methodologies to each other. We compared the found results by pairs using the Mann-Whitney U test with Bonferroni correction for five tests ($p = 0.017$). When comparing p-values of Pilates and DNS, only Schober's p-value is bigger than 0.01. The DNS concept turns out to be more effective than the Pilates exercise for the solution of four tests $p \leq 0.01$ (Table 6).

Secondly, the DNS and BA methodologies were compared. The findings indicate that the exercise with balance aids is more effective than DNS method in the Stibor's test. The least significant differences are when comparing the pair of PM and BA methodologies. The findings show that the exercise with BA can help activate DSS function more effectively than PM (Table 6).

Results of Questionnaire Survey

In the questionnaire patients were asked several questions related to their feelings after the therapy. The patients responded positively in all exercise categories as to whether they felt better after the exercise and had a sense of better stability after long-term exercise. Based on a questionnaire survey, it was evaluated that no method is inferior in terms of the subjective perception of patients. Also, all the patients in all the groups indicated the motivation to continue exercising. From a therapeutic point of view, it is important to know that none of the activities has a significantly demotivating effect. The second group of questions investigated the feelings related to physical changes. Most of the respondents in all three groups confirmed that they observed the changes in their muscular apparatus after regular exercise. The proportion of the patients who observed these changes was: 60% for PM, 72% for DNS, and 63% for BA. Even higher propor-

Table 4. *Overview of improvements in individual methodologies and monitored signs*

Observed issue	Pilates	Dynamic neuromuscular stabilization	Balance aids
Thomayer	2.34	3.62	2.86
Schober	1.28	1.90	1.22
Stibor	1.40	2.50	1.54
Intra-abdominal pressure	0.80	1.76	1.52
Pain	1.96	2.52	2.00

Table 5. *Kruskal-Wallis test for samples*

	Thomayer	Schober	Stibor	Intra-abdominal pressure	Pain
Chi-square value	6.271	8.110	15.383	22.787	9.625
DF	2	2	2	2	2
p-value	0.043	0.017	< 0.001	< 0.001	0.008

Table 6. *Mann-Whitney U test for three pairs of applied methodologies*

Compared pair		Thomayer	Schober	Stibor	Intra-abdominal pressure	Pain
Pilates vs. DNS	Mann-Whitney U	180.50	190.00	123.50	90.00	178.50
	Z	−2.59	−2.42	−3.71	−4.87	−2.99
	p-value	0.010	0.016	< 0.001	< 0.001	0.003
DNS vs. balance aids	Mann-Whitney U	251.50	185.50	156.50	275.50	201.50
	Z	−1.19	−2.50	−3.05	−0.79	−2.34
	p-value	0.23	0.012	0.002	0.431	0.019
Pilates vs. balance aids	Mann-Whitney U	255.00	305.50	306.00	150.00	309.50
	Z	−1.13	−0.14	−0.13	−3.45	0.068
	p-value	0.26	0.89	0.89	0.001	0.95

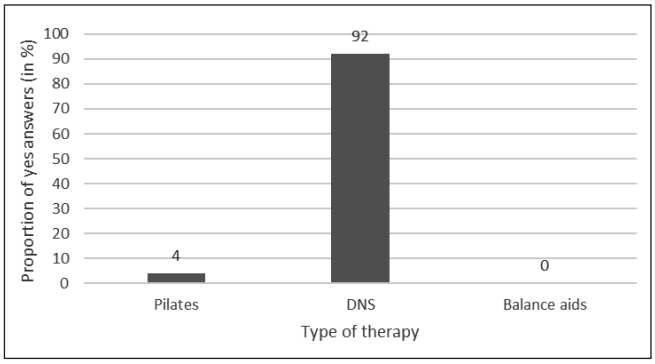

Fig. 1. *Proportion of people perceiving chosen method difficult.*

tions of the patients noted in individual groups the subjectively increased balance while walking. In the Pilates group it was 84% of the patients, in the other two groups 88% of the patients. The regular exercise had a positive effect on the patients' perception of physical strength in all three methodologies.

The patients also answered in the questionnaire whether they perceived the chosen method as difficult to implement. The results are presented in Figure 1. While the patients trained by PM and BA did not perceive this exercise as difficult (more precisely, one patient answered yes in the group practicing Pilates), the DNS method was perceived as difficult by most of the patients.

Based on the summary and comparison of all results, it was noted that the most effective method is DNS for activating the DSS function and thereby affecting the chronic pain in the lumbar area of the spine and lower back. The group of patients that systematically practiced this method regularly achieved improvement in four observed parameters. We improved the dynamic properties of the spine, induced the function of DSS activity and alleviated or eliminated chronic pain. All patients told us that they felt better after the therapy and their muscle imbalances were equalled out. The second in the order was the BA method and third in order was the Pilates method. The data are presented in Table 4.

DISCUSSION

Spinal pain is a common problem that is affecting an increasing number of people even in the younger age groups. Up to 85% of these pains are of a functional origin, i.e., without a clear aetiopathogenetic cause. Due to its prevalence, it is not only an individual problem, but also a societal problem with a significant economic burden on the healthcare system (15). This is mainly caused by the increasing proportion of the factors that have a negative effect on health, such as a lack of exercise, sedentary stressful jobs, which also result in more frequent incapacity for work (16). If the disease is not diagnosed in the early stages, it leads to irreversible changes in the spine with impaired mobility (17). The study compares the effectiveness of three types of exercises on pain perception, DSS function and spine development. All the patients included in the group suffered from chronic low back pain.

In the first observed group of the patients in our study PM was practiced, which involves in addition to individual muscle groups and segments also the deep and superficial muscle system. It improves stability, coordination, mobility, and flexibility of the spine, which was confirmed in our study. Better dynamics of the spine were measured in the exit examinations, and an improvement in the Thomayer's and Schober's distance was observed in 92% of the patients. When the patients perform the exercises, they focused on concentrated breathing that allowed them to maximize the body's ability to stretch and by removing muscle tension they achieved optimal body control. By inducing the diaphragmatic type of breathing of the patients, 100% of them activated an improvement in the involvement of the DSS function as a statement of the intra-abdominal pressure after this therapy. After exercising by this method, the key changes are better body posture, improvement of the muscle balance and work of the diaphragm, which leads to a reduction or elimination of back pain in a relatively short time (18).

In the second group, DNS techniques influenced the function of the muscles in their postural locomotion function. It is important to influence trunk stabilization, while it is necessary to focus on improving the rigidity and dynamics of the chest, influencing the straightening of the spine, practicing the postural breathing stereotype and stabilizing function of the diaphragm. By the activity of the diaphragm, we were able to activate the DSS function in all patients and we managed to significantly improve the dynamics of the spine. By setting the starting position, the DSS function of the spine is reflexively activated, ensuring the strengthening of the trunk, back, and the upper and lower limbs. In the observed group were achieved the activity of the function of deep stabilizers and the straightening of the spine, the correct development of individual sections of the spine.

In the third group were tested and carried out the exercises with balance aids and pre-selected parameters, which were subsequently evaluated in the exit examinations. The improvements were found in the measurements of the development of the spine and in the activity of the deep stabilization system in 81% of the group after three months of exercise and the pain relief was confirmed by 100% of the patients. Static training requires holding a constant position of the body and holding a constant position of the centre of gravity in relation to the balance aid. After mastering of holding the static balance, dynamic balance training can begin. Initially the monitored group, patients had to practice the static balance and activation of the DSS function, and then we included the exercise of dynamic positions. Balance ability was improved by systematic training with the removal of the vision analyser, which ensured a 10–15% higher level of balance ability than when using exercises under visual control. Exercising on unstable aids, apart from the muscles which were exercised, was also involved the supporting muscle apparatus – deep muscles that worked together to hold the upright position of the body. Holding the balance was externally presented by strengthening the abdominal, lumbar, and gluteal muscles (19). By strengthening the given parts in the group, better stability and muscle imbalance was reduced. Body movements became efficient, precise, and coordinated with a decrease in chronic fatigue. This resulted in higher activity of the deep stabilization system with minimal energy used. The differences are in the regularity of the exercise. In the groups using the DNS and balance aids, most patients (96% and 92%, respectively) attended the therapy regularly. The noticeable difference is in the first group, where less than two-thirds of the patients practiced regularly. It is the reduced regularity that could potentially reduce the effectiveness of the given exercise.

CONCLUSIONS

By comparing the three methods it was noted that each of them has its own positive reaction to the pain and the muscular apparatus. The most appropriate method to affect DSS function appears the DNS concept, where was the most significant improvement in DSS activation and the most significant reduction in chronic low back pain. Second in the order is the exercise with BA and the third PM method, where we did measure improvement, but compared to the previous two methods, the changes were significant.

Conflicts of Interest

None declared

REFERENCES

1. Kasík J, et al. [Vertebrogenic root syndromes]. Prague: Grada; 2002. Czech.
2. Tyrlíková I. [Neurology for nurses]. Brno: Národní centrum ošetřovatelství a nelékařských zdravotnických oborů; 2003. Czech.
3. Vrba I. [Differential diagnosis of back pain]. Med Praxi. 2008;5(5):208-12. Czech.
4. Hakl M. [Back pain treatment]. Cas Lek Cesk. 2018;157:62-6. Czech.
5. Kolar P, Sulc J, Kyncl M, Sanda,J, Cakrt O, Andel R, et al. Postural function of the diaphragm in persons with and without chronic low back pain. J Orthop Sports Phys Ther. 2012 Apr;42(4):352–62.
6. La Touche R, Escalante K, Linares MT. Treating non-specific chronic low back pain through the Pilates Method. J Bodyw Mov Ther 2008 Oct;12(4):364-70.
7. Natour J, de Araujo Cazotti L, Ribeiro LH, Baptista AS, Jones A. Pilates improves pain, function, and quality of life in patients with chronic low back pain: a randomized controlled trial. Clin Rehabil 2015 Jan;29(1):59-68.
8. Bogduk N. On the definitions and physiology of back pain, referred pain, and radicular pain. Pain. 2009 Dec 15;147(1-3):17-9.
9. Isacowitz R, Clippinger K. Pilates anatomy. Champaign (IL): Human Kinetics; 2011.
10. Jackson D. [Pilates on the foam roller]. Prague: Euromedia Group; 2013. Czech.
11. Jebavý R, Zumr T. [Strengthening with balance aids]. Prague: Grada; 2009. Czech.
12. Sama. WMA Declaration of Helsinki – ethical principles for medical research involving human subjects [Internet]. New Delhi: Sama [cited 2017 Jan 15]. Available from: http://www.samawomenshealth.in/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/.
13. Childs JD, Piva SR, Fritz JM. Responsiveness of the numeric pain rating scale in patients with low back pain. Spine (Phila Pa 1976). 2005 Jun 1;30(11):1331–4.
14. Kolář P., et al. Clinical rehabilitation. Prague: Alena Kobesová; 2013.
15. Konečná P, Opavský J. [Assessment of motor control disorders in patients with non-specific low back pain]. Rehabil Fyz Lek. 2019;26(4):166-73. Czech.
16. Rychlíková E. [Manual medicine]. 5th ed. Prague: Maxdorf; 2016. Czech.
17. Barnett R, Ingram T, Sengupta R. Axial spondyloarthritis 10 years on: still looking for the lost tribe. Rheumatology (Oxford). 2020 Oct 1;59 Suppl 4:iv25-37.
18. Page P. [Pilates illustrated guide]. Brno: CPress; 2012. Czech.
19. Číž, I. [Technique of exercises in the gym]. Brno: Helbich; 2017. Slovak.

Received March 5, 2024
Accepted in revised form March 14, 2025