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Effects of an Individually Structured Exercise Program on Walking Ability in Patients with Lumbar Spinal Stenosis: A Pilot Study

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Abstract

A limited number of studies in our systematic review suggest that physical exercise may significantly enhance walking ability. Based on these findings, we developed an individualized exercise program primarily incorporating spinal stabilization exercises, mobility drills, and stretching techniques. The objective of this study was to assess the effects of a 12-week supervised and individually tailored exercise program on walking ability in patients with lumbar spinal stenosis (LSS). A total of 26 patients were included at baseline, with 13 randomly allocated to the experimental group and 13 to the control group. Participants underwent physical performance assessments, including the 6-Minute Walk Test (6MWT), the Sit and Reach Test, and McGill's Torso Muscular Endurance Test Battery. A general linear model with repeated measures was employed to analyse differences between groups. Although no statistically significant differences were observed between the experimental and control groups for the 6MWT (p = 0.069), a significant improvement was detected within the experimental group over time. Specifically, a notable increase in walking ability was observed between the first and final measurements (p = 0.001). However, a decline observed in the control group over time, may have influenced the between-group comparisons. While the results indicate significant improvements in walking ability and physical performance tests within the experimental group, it is too early to draw definitive conclusions due to the small sample size and a decline observed in the control group. These results warrant confirmation in larger randomized controlled trials examining long-term functional outcomes.

Keywords: *spinal stenosis, program, performance tests, walking ability, motivation*

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Introduction

Lumbar spinal stenosis (LSS) is a medical condition where the spinal canal narrows in the lower back (lumbar spine), putting pressure on the spinal cord and/or nerve roots. This can lead to pain, numbness, or weakness especially in the legs. The most common cause of lumbar spinal stenosis include degenerative changes and is a very common cause of pain, disability and loss of independence in older adults (Chow et al., 2019).

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Patients usually feel relief of pain when sitting or leaning forward (for example; leaning on shopping cart). As populations worldwide continue to grow older, increasing demand is to be expected on health care systems, including surgery-related resources (Marchand et al., 2021). There has been dramatic rise in spine surgery rates over recent decades, with spinal stenosis being the most common diagnosis associated with spinal surgery in adults over 60 years of age (Macedo et al., 2013). Lumbar spinal stenosis surgery is almost always an elective procedure. A referral for special investigations (advanced imaging, neurological and/or vascular investigations) and/or surgical consultation is recommended if the patient presents with severe intermittent claudication (walking less than 100 meters), new or progressive lower limb weakness, and failure to respond to an appropriate/intensive course of nonsurgical care, as determined by the patient's quality of life and expectations (Bussières et al., 2021; Dobkin, 2019). Although LSS is the most common reason for spine surgery in older adults, most people with neurogenic claudication receive non-operative care. It is also recommended prior to receiving surgical intervention. In an updated systematic review for non-operative treatments for LSS, there are explained evidences that mild to moderate cases often respond well to conservative care. Non-surgical management of lumbar spinal stenosis is generally recommended as the initial step of treatment due to its lower risk profile and cost-effectiveness. Conservative interventions—such as physical therapy can alleviate symptoms in many patients without exposing them to the inherent risks associated with surgical procedures (Ammendolia et al., 2022), but the remaining comparisons provide either low-quality or very low-quality evidence. This lack of evidence limited our ability to make conclusions on the effectiveness of most non-operative treatments.

It is the reason why aim of this pilot study was to develop and pilot an individually tailored 12- week experimental controlled program to compare with control group in which participants continue with their daily routines and usual care. Usual care also included any physiotherapy treatments through public health care. The main aim was to improve patient's daily step count average and walking distance of 6- Minute walk test.

There is now moderate evidence that a multimodal structured 6-week programme consisting of manual therapy and exercise with or without education is an effective treatment approach. A recent systematic review and meta-analysis of randomised controlled trials (RCTs) evaluating conservative therapies for LSS also concluded that manual therapy and supervised exercises significantly improve outcomes compared with self-directed or group exercises (Comer et al., 2024; Macedo et al., 2013; Marchand et al., 2021; Minetama et al., 2019). A multimodal approach to the treatment of LSS would appear to be a rational approach given the complexity of neurogenic claudication with underlying physical, functional and psychosocial factors impacting recovery (Ammendolia et al., 2022). The differing pathophysiology may require different treatment approaches (Bagley et al., 2019).

In the last systematic review from Comer et al. (2024) more than 75% exercise interventions of the included trials were supervised exercises, land-based exercises, some form of lumbar lordosis reducing/flexion-based exercises and some form of aerobic fitness exercises (walking, cycling, or general fitness). Exercise interventions which were included, were performed at least twice a week and lasted from 6-11 weeks. Supervised exercises were delivered once to twice weekly and home exercises prescribed daily or twice daily. With home exercises, the frequency of contact with clinicians varied widely. Studies published in the last 5 years were less likely to include passive modalities and more likely to include a psychologically informed approach. The treatment effects of various exercise intervention components varied across the three outcomes of symptom severity, physical function, and walking capacity. Research to date investigating physical activity is effective for improving pain and function. In the study Norden et al. (2017) preliminary data suggest that a pedometer-based physical activity intervention is effective for improving pain, mental health, and fat mass in people with LSS. The gaps in current non-operative interventions are lack of high-quality comparative evidence, heterogeneity in treatment protocols, limited long-term effectiveness, understudies patients stratifications and inadequate integration of multimodal approaches. Therefore, the aim of this pilot study was to evaluate how was our individually structured program successful when implemented it into practise.

Methods

Study design

This study was conducted as a pilot, single-centre, prospective, randomised, blind, controlled experiment.

Patients

Inclusion criteria for entering the study were: 1) age between 50 and 80 years, 2) a diagnosis of lumbar spinal stenosis (LSS) confirmed by magnetic resonance imaging (MRI), 3) clinical symptoms associated with LSS (neurogenic claudication), 4) the ability to reach the gold standard of walking distance (250 m), 5) being an appropriate candidate for LSS surgery as determined by an orthopaedic surgeon and 6) signed consent for participating in the study. Exclusion criteria were: 1) early onset of stenosis symptoms (disability to walk 250 m), 2) associated spinal defects (spondylolisthesis of a high degree), 3) vascular claudication, 4) diabetic polyneuropathy, 5) presence of a neurological disease affecting the patient's functionality, 6) patients with fibromyalgia or systemic inflammatory diseases.

All participants were patients of an orthopaedic department within a university hospital in Ljubljana and were invited over a telephone call to participate in the study. Twenty-six patients (17 women and 9 men) consented to participation. After the first measurements the randomization was done by Research Randomizer version 4.0 over Chrome.

This study was approved in advance by Ministry of Health, The Commission for Medical Ethics of the Republic of Slovenia. Each participant voluntarily provided written informed consent before participating.The effect size was calculated a priori, as this pilot study forms part of a doctoral research project. The number of subjects before randomization for the research should be 76 subjects, based on the calculated sample size. 38 in the control and 38 in experimental group. At the outset of the study, we selected 26 patients for inclusion in the initial group, which was designated as the pilot cohort. This pilot group was used to evaluate the feasibility of the study protocol, refine data collection procedures, and inform potential modifications for the larger-scale investigation.

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Interventions

Kinesiotherapy training and supervision

Participants were assigned to small, homogeneous groups of four individuals. Sessions were conducted twice per week at a movement studio.

During the first two weeks, training focused on body repositioning techniques to promote optimal posture and reduce lumbar lordosis. To facilitate adherence, participants were permitted to record exercise demonstrations on their mobile devices for reference during home practice. They were instructed to perform the prescribed exercises as frequently as necessary, with a minimum requirement of once per day.

Each session lasted between 60 and 75 minutes and included treadmill or outdoor walking as a warm-up, aimed at improving overall physical condition and increasing daily step count. Over the course of the 12-week intervention, exercises were progressively intensified by increasing repetitions, sets, or complexity, depending on individual progress. Previously introduced exercises were reviewed at each session, and new exercises were systematically incorporated. A maximum of three to six new exercises were introduced per session.

To enhance proprioception and movement awareness, various different accessories were utilized. The program emphasized not only physical conditioning but also the development of movement control and body awareness to support long-term symptom management and functional improvement.

Their abilities were measured at baseline, at 8 and 12 weeks using different parameters. In this pilot study we would like to verify if patient's step count, strength of the trunk stabilizers and flexibility improve over 12 weeks.

Walking-diary

As part of the intervention, participants systematically monitored their daily step count using a walking diary. Those who owned a smartwatch utilized it for step tracking, while others acquired different pedometers to record their daily walking activity. During the first week, participants documented their total daily step count and/or walking distance. This initial monitoring phase enabled us to assess participants baseline activity levels and identify individuals requiring additional guidance on walking strategies.

Based on established recommendations in the literature, participants whose baseline daily step count was fewer than 7,500 steps were classified as requiring additional intervention. During the first two weeks, these participants were instructed to progressively increase their baseline step count by at least 500 steps on a minimum of three days per week. Furthermore, they received structured guidance on optimizing their walking routine, including considerations regarding the timing, location, and potential walking companions.

In weeks three and four, participants were encouraged to increase their baseline step count by 500 steps on at least five days per week. In weeks five and six, the target was raised to an additional 1,500 steps on a minimum of three days per week. From the seventh to the twelfth week, participants were advised to further increase their baseline step count by 1,500 steps on at least five days per week. At the final assessment, participants reported their average step count for the last week of the program to evaluate overall improvements in physical activity levels.

Measurements

All measurements were performed at Faculty of Sports, University of Ljubljana. For the purpose of measurements, we required students from the Faculty of Sports to help us with patients. At each station, two students from the Faculty of Sports were assigned to conduct the test across all measurement sessions. This approach ensured that they were familiar with the test and helped prevent deviations in the results.

6- Minute walk test

The test was performed on 30 m long track with markings at 5 meters. The distance covered over a time of 6 minutes is used as the outcome by which to compare changes in performance capacity. If the participant stops at any time prior, they can also continue walking whenever they feel able.

Sit and reach test

This test is one of the linear flexibility tests which helps to measure the extensibility of the hamstrings and lower back. The distance reached is recorded to assess flexibility, with longer reaches indicating greater flexibility. We used the level of the feet as level zero, so that any measure that does not reach the toes is negative, and any reach past the toes is positive measure how far the participant reaches forward.

McGill's torso muscular endurance test battery

This test battery consists of 3 tests. Trunk flexor endurance test, trunk lateral endurance test on both sides and trunk extensors endurance test. They are all timed tests involving a static, isometric contraction of muscles, stabilizing the spine until the individual exhibits fatigue and can no longer hold the assumed position. Each individual test is not a primary indicator of current or future back problems. Stuart McGill has shown that the relationships among the tests are more important indicators of muscle imbalances that can lead to back pain.

Results

From September 2024 to December 2024, 8 of 26 participants did not complete the follow up. 7 of them were in control group and 1 in experimental group. All of them did not attend their second measurement. 3 of them did not provide a reason for withdrawal. Other reasons for declining enrolment included time and family commitments, other health issues or deterioration in their condition. See Figure 1 for the CONSORT diagram regarding patient flow through the study.

Table 1 demonstrates the baseline characteristics of all participants in comparison to outcome measures after 12-weeks program. Patients in experimental group using walking diaries (self-recorded using a pedometer) increased their daily step count by an average of 2572 steps per day which is significant improvement ($p = 0.002$), especially for people who start with a low baseline step count (Lang et al., 2021). As we see the results of 6-Minute walk test (6MWT, $p = 0.004$), the walking distance increased from 366 meters to 479 meters. Significant improvements were observed in flexibility (SART, $p = 0.038$), and core endurance (McGill tests, all $p < 0.05$). No significant change was found in BMI ($p = 0.812$), suggesting that body weight remained stable throughout the intervention. The largest improvements were in McGill flexors ($p = 0.001$) and 6MWT distance ($p = 0.004$), indicating significant gains in core endurance and walking ability.

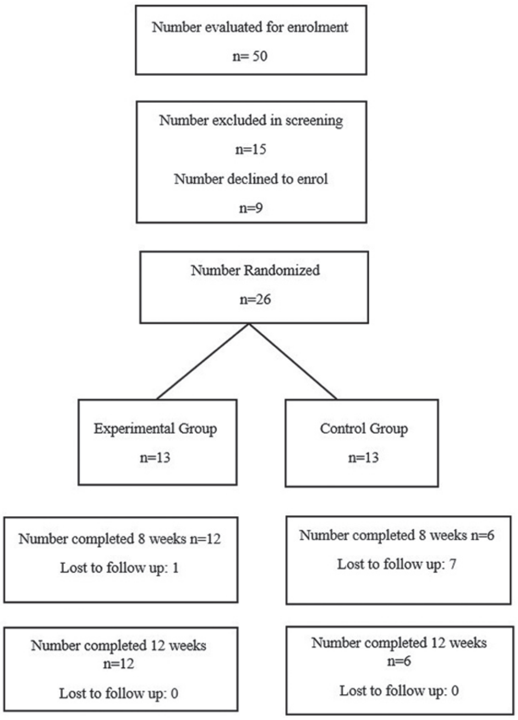

Figure 1. CONSORT Diagram

Table 1. Baseline comparison for personal, anthropometric and outcome measures

	Baseline (n=26) Mean (SD)	Outcome (n=18) Mean (SD)	p-value
Age	67.5 (6.33)	66 (3.23)	-
BMI (kg/m2)	30.94 (5.26)	30.70 (5.28)	0.812
Gender			
Female	17	11	
Male	9	7	
Daily steps	2748.69 (1123.44)	5320.75 (2761.91)	0.002
6-Minute Walk Test (6MWT, meters)	365.88 (109.99)	478.67 (97.52)	0.004
Sit and Reach Test (SART, cm)	11.11 (12.39)	16.93 (10.37)	0.038
McGill's Torso Muscular Endurance Test (seconds)			
Flexors	45.03 (36.67)	95.88 (54.39)	0.001
Extensors	28.02 (20.76)	50.57 (36.22)	0.012
Right side	31.73 (28.35)	56.26 (35.37)	0.015
Left side	32.67 (36.53)	56.48 (38.89)	0.019

Note. BMI: Body mass index

Table 2 demonstrates differences within control and experimental group for 6-Minute walk test. The experimental group shows consistent and significant improvement in walking performance over time. The control group shows some early improvement (1 to 2, p= 0,028), but over time there is no significant improvement (2 to 3, p= 0,388). The most significant improvement is between second and third measurement (p= 0,000) in experimental group, probably because from the seventh to the twelfth week, participants were advised to further increase their baseline step count by 1,500 steps on at least five days per week.

In Table 3 both groups improved early on (1 to 2), but only the experimental group shows sustained, statistically significant improvement from start to an end of the intervention (p= 0,000).

Table 2. Differences within groups: 6- Minute walk test

	p	
	Control Group	Experimental Group
6MWT_1& 6MWT_2	0.028	0.004
6MWT_2& 6MWT_3	0.388	0.000
6MWT_1& 6MWT_3	0.099	0.001

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Table 3. Differences within groups: Sit and reach test

	p	
	Control Group	**Experimental Group**
SART_1& SART_2	0.006	0.002
SART_2& SART_3	0.852	0.117
SART_1& SART_3	0.051	0.000

Table 4. Differences within groups: McGill flexors test

	p	
	Control Group	**Experimental Group**
Flex_1& Flex_2	0.552	0.392
Flex_2& Flex_3	0.023	0.001
Flex_1& Flex_3	0.120	0.001

In Table 4 there is only one significant change in control group between second and third measurement (p=0,023) and no significant long-term change. In experimental group there is no significant improvement between first and second measurement (p=0,392) probably because in first two weeks the intervention is more focused in body repositioning and not as much in strength improvement.

Table 5 demonstrates us significant improvements across all timepoints in experimental group. Participants in this study were presented with weak core extensor muscles due to their condition, the exercise program was primarily designed to target and strengthen the deep core musculature. Emphasis was placed on improving the stability and endurance of these foundational muscles to support overall functional movement and postural control (Lurie & Tomkins-Lane, 2016; Peterson et al., 2021).

Table 5. Differences within groups: McGill extensors test

	p	
	Control Group	Experimental Group
Exte_1& Exte_2	0.028	0.030
Exte_2& Exte_3	0.201	0.032
Exte_1& Exte_3	0.092	0.003

Table 6. Differences within groups: McGill right and left side plank test

	p	
	Control Group	**Experimental Group**
Rside_1& Rside_2	0.170	0.001
Rside_2& Rside_3	0.771	0.172
Rside_1& Rside_3	0.511	0.010
Lside_1& Lside_2	0.192	0.005
Lside_2& Lside_3	0.750	0.235
Lside_1& Lside_3	0.323	0.018

In Table 6 the experimental group showed clear and statistically significant core strength improvements on both sides over time, especially early on, on the right side (p= 0,001) and on the left side (p=0,005). The control group didn't show any significant changes. This pattern aligns with what we can see in results of all tables above: the experimental intervention appears to be effective, with early gains that are sustained over time.

Discussion

The main aim of the present pilot study was to investigate whether patients could improve their walking distance after having completed a walking program. The results of the present study demonstrate that the program indeed improved all performance parameters. The average maximum walking distance (6- Minute walk test) improved from 366 m to 479 m, and as reported in the diaries from 2749 to 5321 steps per day. Mean daily baseline step count was similar to values reported in a systematic review on pedometer interventions for chronic low back pain which ranged from 2337 to 5563 steps (Vanti et al., 2019) and is similar to the step count findings published by McDonough et.al (2010). The second aim of the study was to assess whether a personalized and progressively advanced exercise program would lead to improvements in patient's flexibility and core strength. Significant improvements were observed in flexibility (SART, p = 0.038), and core endurance (McGill tests, all $p < 0.05$). To date, no studies have been identified that directly compare the same assessment tests as those employed in our pilot study. To our knowledge, this is the first pilot study comparing individually tailored program which includes also walking program and structured home-based exercises compared with usual care or no treatment. All other studies evaluating non-operative interventions provided insufficient quality evidence (Ammendolia et al., 2022). The majority of exercise interventions in the trials we reviewed relied on theoretical rationales. These rationales include theory-driven recommendations of flexion-based/lordosis-reducing exercises and trunk muscle control exercises for relieving the posture-related symptoms of lumbar spinal stenosis and neurogenic claudication. Despite these limitations, non-operative treatments are often justified based on their biomechanical and functional rationale. Targeted physical therapy and exercise programs aim to improve lumbar spine stability, posture, and muscular support, thereby reducing mechanical compression on neural structures. Additionally, interventions that promote pelvic alignment, core strengthening, and improved gait mechanics can alleviate neurogenic claudication and enhance functional capacity without directly altering anatomical stenosis. However little or no detail was provided to explain the selection of specific exercise intervention parameters and components (Chow et al., 2019; Comer et al., 2024; Marchand et al., 2021; Minetama et al., 2019).

Limitations

This pilot study had several limitations. The sample size was relatively small due to challenges in patient recruitment, which included strict eligibility criteria, limited patient availability, and reluctance to participate. Probably because of older population who is less willing to change their daily routine. We also have some logistical issues because measurement sessions and intervention were executed in Ljubljana and recruited patients were from all over the Slovenia. Additionally, an unexpected decline in the control group potentially introduced bias and affected the comparability of the results.

Despite its limitations, this study has several strengths. It provides valuable insights into characteristics of lumbar spinal stenosis patients, their symptoms and overall physical condition including ability to walk, flexibility and core muscles strength. Additionally, the findings offer potential clinical implications, which will guide a future research and improve patient care. Our intention is to include more patients in research, but due to the unexpected decline in the control group we first need new strategies to retain patients in the study. We start with regular check-ins which include phone calls, emails or short in-person meetings to give them full support. We try with motivation techniques as providing positive reinforcement and emphasizing their importance in the study. We are also offering them individual consultations to teach them some exercises which they can perform at home. One part of new strategy is also delayed intervention. We inform them that they will have access to the full exercise program after the study concludes.

Conclusion

The pilot study results suggest that the programme is feasible, acceptable, and potentially useful for improving walking capacity, flexibility and core muscles strength. Further work is needed to assess the clinical differences between control and experimental group and larger sample size to give more reliable subgroup analysis. This study supports the feasibility of individualized structured exercise programs in improving functional outcomes in LSS and highlights the need for their integration in conservative management pathways. Enhancing these physical parameters can improve functional mobility, reduce pain, and potentially delay or avoid surgical intervention. A structured, individualized approach may offer superior outcomes compared to generic physiotherapy or unsupervised activity. By comparing against real-world standard care, this study provides practical evidence on whether personalized programs offer added value in typical clinical settings, supporting informed decision-making in treatment planning. The overarching aim of this research is to contribute to the alleviation of burden on the healthcare system by supporting the implementation of effective non-operative treatment strategies for lumbar spinal stenosis in clinical practice. By demonstrating the feasibility and potential benefits of conservative management, this study seeks to promote evidence-based, accessible, and cost-effective care pathways for patients with degenerative spinal conditions.

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