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Comparing the effectiveness of a course of dynamic neuromuscular stabilization exercises and sensory-motor training on pain and trunk endurance in sciatica patients

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Abstract:

Background: Sciatica is a neuropathic disorder involving the nerve roots from the L3 vertebra downward. Its most prominent symptom is leg pain that radiates from below the knee down to the toes. The aim of the present study was to compare the effects of Dynamic Neuromuscular Stabilization (DNS) and Sensory-Motor Training (SMT) on pain and trunk endurance in patients with sciatica.

Methods: This study was a semi-experimental field study conducted using a pre-test and post-test design. The study population consisted of 30 non-athletic women with sciatic nerve injury, selected through convenience sampling and randomly assigned to two groups of 15: a Sensory-Motor Training (SMT) group and a Dynamic Neuromuscular Stabilization (DNS) group. The Quebec Back Pain Disability Scale was used to assess pain intensity, and trunk flexion test was employed to evaluate lumbar endurance. The intervention included exercise sessions held three times per week, each lasting one hour, over a period of eight weeks. Data analysis was performed using analysis of covariance (ANCOVA), and a significance level of $p \leq 0.05$ was applied to examine the effects of all variables.

Results: The results showed that the Dynamic Neuromuscular Stabilization (DNS) exercise group exhibited a greater decrease in sciatic nerve pain from baseline to post-intervention (DNS: from 60.34 to 40.51); however, no statistically significant difference was observed between the groups ($p = 0.69$). In contrast, the sensory-motor training (SMT) group demonstrated a more pronounced improvement in trunk endurance from baseline to post-intervention (SMT: from 92.1 to 67.16), with a statistically significant difference between groups ($p < 0.005$).

Conclusion: Both training protocols can be effectively utilized as rehabilitation methods to improve the condition of individuals suffering from sciatic nerve pain.

Keywords: neuromuscular stability exercises, sensory-motor training, pain, trunk endurance, sciatica

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Introduction

The sciatic nerve is the largest nerve in the human body, formed by the fusion of five nerve roots (L4 to S3) that originate from the lumbosacral region. This nerve consists of two main branches: the tibial nerve and the common peroneal nerve, which arise from different segments [1]. In normal anatomical conditions, the sciatic nerve passes from the pelvis into the gluteal region and runs beneath the piriformis muscle. It then travels down the posterior thigh and, in the proximal region, divides into the tibial and common peroneal nerves [2]. Sciatica refers to pain that appears in the nerve networks of the legs and can affect individuals of all ages, from young to elderly. It is important to note that the causes of sciatic pain can vary depending on the individual's age and condition [3]. Overall, it is estimated that 5% to 10% of patients with low back pain experience sciatica [4]. Symptoms of sciatica can range from mild pain to complete disability, and may include burning sensations, numbness, and even severe muscle weakness. In many individuals, this pain is associated with a significant decline in physical function [5]. Pain and burning along different parts of the sciatic nerve particularly the peroneal region are among the most prominent and painful symptoms of this condition [6]. This distressing experience can severely limit daily activities such as standing, walking, and even sleeping [7]. Impairment in proprioception can lead to dysfunction throughout the entire human motor system and delay muscular responses essential for joint stability [8]. Most existing studies have primarily focused on the lumbar region, while many pain-related factors have not been adequately considered in these investigations [9]. Previous research has primarily concentrated on the lumbar area, often overlooking important contributors such as proprioceptive deficits, neuromuscular control impairments, and muscle endurance reductions. The current study addresses this gap by simultaneously evaluating pain, trunk endurance, and dynamic balance in sciatic patients, providing a more comprehensive understanding of therapeutic effects.The underlying mechanisms contributing to this condition have led to the development of various treatment methods for sciatica. These approaches are sometimes pharmacological and other times based on movement therapy. Notably, significant positive effects such as substantial pain reduction and improved function have been reported primarily from non-pharmacological methods, including exercise therapy and massage [10]. Evidence suggests that appropriate exercises and massage can be beneficial for individuals with chronic nonspecific low back pain by improving functional capacity and reducing pain, thereby enhancing the quality of daily activities. Research findings show that massage has a statistically significant effect on reducing pain in these individuals. Overall, the results indicate that massage is effective in alleviating pain by promoting fresh blood circulation in tissues and helping to eliminate chemical waste products that cause chronic pain [11].Another active treatment method in this field is aquatic exercise therapy. Research has shown that performing stabilizing exercises in water can significantly reduce pain and improve balance in individuals suffering from low back pain [12]. In cases where pharmaceutical and surgical treatments have been employed for this condition, despite the recognized ability of peripheral nerve axons to regenerate, the outcomes and recovery following nerve graft surgery remain highly variable. Factors such as the distance between the lesion and the innervated site, the rate of axonal regeneration, the gradual decline in the regenerative capacity of severed nerves, and muscle atrophy are among the key limitations affecting post-surgical results [13]. Exercise is a cost-effective and practical method widely accepted as an effective treatment for musculoskeletal disorders. As a therapeutic approach, exercise involves physical activities aimed at correcting dysfunctions and enhancing physical and cognitive performance, which can positively impact overall health [14]. Therapeutic exercises are generally classified into various categories, such as stretching exercises, strengthening/resistance training, aerobic exercises, motor control/stabilization exercises, and mind-body practices [15]. The effectiveness of exercise therapy as a complementary or interventional treatment for patients with sciatic nerve pain has been reported in previous studies. Evidence suggests that structured exercise programs can aid in the regeneration of damaged nerves, reduce pain symptoms, and improve physical condition [16]. In past research, various treatments have been proposed for managing low back pain, including medication, hydrotherapy, massage therapy, exercise therapy, biofeedback, hypnosis, acupuncture, physiotherapy, and, in some cases, surgery. Nowadays, instead of prolonged bed rest, physical activity and exercise therapy are recommended for patients with spinal and sciatic pain. Exercise therapy offers numerous benefits for individuals with low back pain, such as pain reduction, strengthening of weak muscles, stretching of shortened muscles, reduction of mechanical stress on the spine, stabilization of hypermobile vertebrae, improvement in posture, and enhancement of physical mobility [17]. In modern corrective movement approaches, it is believed that the root of postural problems is more neuromuscular than anatomical, and even many anatomical issues have neuromuscular origins[18]. One of the latest corrective techniques is the Dynamic Neuromuscular Stabilization (DNS) fundamental movement and stretching technique. This method focuses on regulating intra-abdominal pressure and precisely assessing the quality of stability or movement, aiming to reconstruct the ISSS through specific exercises based on positions developed by infants during their growth[19]. DNS focuses on retraining fundamental movement patterns based on infant developmental stages, aiming to restore core stability through neuromuscular regulation. In contrast, Sensorimotor Training (SMT) emphasizes stimulation of afferent pathways to enhance proprioception and postural control via balance and coordination exercises. Due to their different mechanisms of action, this study aims to compare the distinct effects of DNS and SMT on individuals with sciatic nerve pain.

The dynamic neuromuscular stabilization therapy is founded on an accurate evaluation of movement quality and spinal stability through functional exercises based on the developmental positions of movement patterns from birth to early walking. These exercises activate movement patterns necessary for stability in motor chains and dynamic movements in other chains involved in achieving proper activity. The basic principles and techniques of these exercises include general training for maintaining stability, use of appropriate movement patterns for ipsilateral and contralateral limbs, correct limb movements for forward stepping, application of suitable postural movement patterns, stabilization of each segment in involved muscular chains, matching postural function to the required force for movement, using proper breathing patterns to facilitate soft tissue mobility, keeping the spine aligned, progressing movements from basic to more advanced, and avoiding incorrect movement patterns[20].

Additionally, Sensorimotor Training (SMT), introduced by Janda, is a crucial process in rehabilitation. Janda emphasized the importance of stimulating the entire sensorimotor system through afferent and efferent mechanisms, stating that environmental information must first be addressed and corrected. The cerebellum and other subcortical regions provide movement capabilities based on primitive movement patterns, while the parietal and frontal cortical lobes program movement sent via muscular efferent pathways. Sensorimotor training involves passive facilitation of afferent pathways that strongly influence balance and posture control. Studies have shown that neuromuscular training programs are more effective than strengthening exercises in improving muscular responses. Sensorimotor exercises have repeatedly demonstrated positive effects on proprioception, postural stability, endurance, and can enhance strength. These exercises include static, dynamic, and functional types, facilitated through three mechanisms to enhance afferent motor pathways: 1) increasing proprioception in three key areas—the plantar surface of the foot, cervical spine, and sacroiliac joints; 2) stimulating the vestibulocerebellar system via balance exercises; and 3) influencing the midbrain through primitive displacement activities[21].

Sensorimotor training and dynamic neuromuscular stabilization are recognized as some of the most effective methods for treating various neurological disorders. These protocols, commonly used in corrective exercises, can positively impact multiple health factors in individuals. Sensory-motor therapeutic techniques based on Janda's approach have demonstrated positive effects on pain-related factors, range of motion, balance control, and postural stability in individuals with neuromuscular impairments, especially when coordination and stability are emphasized. Additionally, it has been shown that DNS exercises play a significant and effective role in improving trunk muscle function and endurance. These exercises appear to be beneficial in addressing sciatica, a common condition characterized by high levels of pain and disability as well as reduced muscular health factors.

Despite extensive research on the effects of SMT and DNS on various types of low back pain and conditions such as multiple sclerosis, elderly individuals, and stroke patients, no studies have yet examined or compared the effects of these exercises on individuals with sciatic nerve pain, leaving many questions unanswered. While prior studies have investigated stabilization and sensorimotor exercises in patients with radicular low back pain, no research has directly compared the effects of DNS and SMT specifically in individuals suffering from sciatic nerve pain. Given the clinical distinctions between radiculopathy and sciatic nerve involvement, this study fills an important niche in the rehabilitation literature.

Therefore, the aim of this study was to investigate the effectiveness of sensorimotor training and dynamic neuromuscular stabilization protocols on individuals suffering from sciatic nerve pain and to compare the impact of these interventions. Accordingly, this research compared the effects of sensorimotor training (SMT) and dynamic neuromuscular stabilization (DNS) on pain, trunk endurance, and dynamic balance in individuals with sciatic nerve pain[22].

Material and methods

This study employed a semi-experimental field design using a pre-test and post-test approach. Given the purposive selection of participants based on specific inclusion and exclusion criteria, the research falls under the category of quasi-experimental studies. It was conducted cross-sectionally in terms of timing and is considered applied in terms of its practical outcomes.The statistical population included 30 non-athletic women suffering from sciatic nerve injury. The researcher initially accessed 41 individuals through a public call, and based on the study criteria, 30 eligible participants were selected through convenience sampling. These individuals were then randomly divided into two groups of 15: one group performed sensorimotor training (SMT), and the other engaged in dynamic neuromuscular stabilization (DNS) exercises.

All participants, aged between 35 and 45 years, were referred to the Health and Corrective Exercise Clinic of the Foolad Mobarakeh Sepahan Sports Complex in Isfahan and voluntarily agreed to take part in the study. They were assigned to either an experimental group or a control group, each consisting of 15 participants.To assess pain intensity, the Quebec Back Pain Disability Scale was used. This questionnaire includes 20 five-option questions that evaluate the level of pain during daily activities. Each item is scored from zero (no pain) to four (inability to perform the activity), with the total score ranging from zero to one hundred. A score of zero indicates no pain, 25 signifies moderate pain, 50 indicates high pain, 75 reflects severe pain, and scores above 75 represent extreme pain, where the person is unable to function. Only individuals with moderate to severe pain were included in the study.To measure lumbar endurance, the 60-degree trunk flexion test (a form of sit-up) was employed. In this test, the participant maintains a 60-degree trunk flexion position relative to the ground while lying down, and the duration for which the position is held is recorded. Participants in each group followed their respective training protocols for 8 weeks, with three sessions per week, and each session lasting between 50 to 60 minutes. At the end of the training period, the same tests conducted prior to the intervention were administered again to assess changes.

Training protocol

In this study, Dynamic Neuromuscular Stabilization (DNS) and Sensorimotor Training (SMT) protocols were utilized. These training programs were selected based on prior scientific research, and following approval by medical professionals, were prescribed to the participants. After initial instruction, all participants engaged in their respective training regimens for a duration of eight weeks under the direct supervision of the researcher. Each SMT session included the following structure: a 5-minute walking warm-up and 5 minutes of stretching exercises, followed by the main training phase. The core session lasted 30 minutes during the initial weeks and gradually increased to 45 minutes in the later stages. A 5-minute cool-down concluded each session. Progression in these exercises was guided by the principle of progressive overload, primarily through increased duration or repetition of exercises. Each DNS session consisted of three phases: warm-up (10 minutes), main DNS exercises (45 minutes), and cool-down (5 minutes). During the first four sessions, foundational DNS postures and proper breathing patterns were taught and practiced. In each position, participants performed 10–15 deep breaths across three sets, with 30–60 seconds of rest between sets.

A key principle in DNS training is individualized progression. Exercise intensity was adapted based on the participant's capacity and the quality of breathing control. Participants were allowed to advance only if they demonstrated correct performance along with proper breathing. If either element was lacking, progression to the next movement pattern was restricted. To add variety and increase load, resistance tools such as dumbbells and resistance bands (TheraBands) were introduced after participants had mastered basic movement patterns. The core DNS protocol—based on muscular chain reflexes—was structured across three levels: basic, intermediate, and advanced. The intensity and complexity of exercises increased in accordance with each individual's ability. Initially, lower-intensity exercises were performed, gradually progressing toward moderate intensity by the final sessions. Advancement to higher levels was permitted only after full mastery of the prior level. The researcher monitored each session, evaluated the participant's performance, and adjusted the following session's training load accordingly.

Data analysis

Descriptive and inferential statistical methods were used to analyze the data. In the descriptive statistics section, measures of central tendency (mean) and measures of dispersion (variance and standard deviation) were calculated. The normality of the data distribution and the homogeneity of variances were assessed using the Shapiro-Wilk test and Levene's test, respectively. In the inferential statistics section, due to the presence of pre-test and post-test measurements and the potential influence of pre-test scores on post-test outcomes, analysis of covariance (ANCOVA) was employed to control for these effects and to compare groups. The significance level for all statistical tests was set at $P \leq 0.05$.

Results

Table 1. Kolmogorov-Smirnov Test of Residuals

p-value	Degrees of Freedom	Test Statistic	
0/163	30	0/136	**Residuals of Pain Intensity ANCOVA**
0/200	30	0/075	**Residuals of Trunk Endurance ANCOVA**

Table 2. Descriptive Statistics of Pain Intensity: Means and Standard Deviations

Difference in Means (Post-test minus Pre-test)	Post-test		Pre-test		Group
	Standard Deviation	Mean	Standard Deviation	Mean	
-3/20	2/53	31/40	2/56	34/60	**Dynamic Neuromuscular Training Group**
-1/00	2/46	34/73	2/55	35/73	**Sensorimotor Training Group**

The mean difference in pain intensity between the pre-test and post-test was reported as −1.00 for the Sensorimotor Training Group and −3.20 for the Dynamic Neuromuscular Training Group. The results indicated that the Dynamic Neuromuscular Training Group demonstrated a significantly greater improvement in pain intensity reduction following the intervention compared to the Sensorimotor Training Group.

Table 3. ANCOVA Test Results for Pain Intensity

p-value	F	Mean Squares	Degrees of Freedom	Sum of Squares	
0/000	240/365	122/077	2	244/154	**Corrected Model**
0/975	0/001	0	1	0	**Intercept**
0/000	316/65	160/821	1	160/821	**Pre-test**
0/000	72/25	36/695	1	36/695	**Groups**

0/508	27	13/713	**Error**
	30	33060	**Total**
	29	257/867	**Corrected Total**

As shown in Table 3, the F-statistic for comparing the two groups was 72.25, with a corresponding significance level (p-value) of 0.000, which is less than the threshold of 0.05. Therefore, with 95% confidence, the null hypothesis stating that there is no difference between the Sensorimotor Training Group and the Dynamic Neuromuscular Training Group is rejected. The results indicate a statistically significant difference in pain intensity scores between the two groups. Furthermore, the Dynamic Neuromuscular Training Group demonstrated a greater reduction in pain intensity from pre-test to post-test compared to the Sensorimotor Training Group, supporting the research hypothesis.

Table 4. Descriptive Statistics of Means and Standard Deviations for Trunk Endurance

Difference in Means (Post-test minus Pre-test)	Post-test		Pre-test		Group
	Standard Deviation	Mean	Standard Deviation	Mean	
2/56	3/97	19/76	3/85	17/19	**Dynamic Neuromuscular Training Group**
3/41	2/23	20/08	1/92	16/67	**Sensorimotor Training Group**

The mean difference in trunk endurance scores between the pre-test and post-test was 3.41 for the Sensorimotor Training Group and 2.56 for the Dynamic Neuromuscular Training Group. These findings indicate that the Sensorimotor Training Group showed greater improvement in trunk endurance following the intervention compared to the Dynamic Neuromuscular Training Group.

Table 5. ANCOVA Test Results for Trunk Endurance

p-value	F	Mean Squares	Degrees of Freedom	Sum of Squares	
0/000	222/562	137/233	2	274/466	**Corrected Model**
0/006	9/048	5/579	1	5/579	**Intercept**
0/000	443/821	273/663	1	273/663	**Pre-test**
0/006	9/06	5/586	1	5/586	**Groups**
		0/617	27	16/648	**Error**
			30	12194/112	**Total**
			29	291/115	**Corrected Total**

As presented in Table 5, the F-statistic for comparing the two groups was 9.06, with a corresponding significance level (p-value) of 0.006, which is below the 0.05 threshold. Therefore, with 95% confidence, the null hypothesis suggesting no difference between the Sensorimotor

Training Group and the Dynamic Neuromuscular Training Group is rejected. The results indicate a statistically significant difference in trunk endurance scores between the two groups. Furthermore, the Sensorimotor Training Group demonstrated greater improvement in trunk endurance from pre-test to post-test compared to the Dynamic Neuromuscular Training Group, supporting the research hypothesis.

Discussion

The findings of the present study demonstrated that both sensorimotor and dynamic neuromuscular training interventions effectively improved trunk performance; however, the sensorimotor training group exhibited greater enhancement in trunk muscle endurance compared to the dynamic neuromuscular group. These results suggest that sensorimotor exercises, by increasing muscle fatigue tolerance and enhancing trunk stability, can significantly improve patients' functional capacity.

Physiologically, sensorimotor exercises stimulate both peripheral and central neural pathways, enhancing motor control and activating deep stabilizing muscles. This finding aligns with the results of Golpayegani et al. (2020), who reported significant improvements in trunk muscle endurance and reduced pain among women with chronic low back pain following Dynamic Neuromuscular Stabilization (DNS) exercises. Their study emphasized the importance of natural neuromuscular developmental patterns in improving trunk and lumbar muscle function [22] .

On the other hand, the present study also revealed a significant reduction in sciatic nerve-related pain in the dynamic neuromuscular group post-intervention. This finding is consistent with that of Hanna et al. (2015), who observed meaningful pain reduction following exercise interventions in similar patient populations [2٣] .

Neuromuscular training appears to enhance trunk stability by improving neural control and the coordination between superficial and deep muscle groups, thereby reducing stress on neural structures. Conversely, sensorimotor exercises enhance proprioception and balance responses, playing a crucial role in rehabilitation and motor function recovery.Given that sensorimotor training requires no special equipment, can be performed at home, and is free of side effects, it can be recommended as a safe, cost-effective, and efficient approach to improving trunk endurance and reducing movement limitations in individuals suffering from sciatic pain.

Conclusion

Pain and reduced trunk endurance are common complications among individuals suffering from sciatic nerve injuries, significantly impairing their quality of life. The overall findings of this study demonstrated that the application of the DNS (Dynamic Neuromuscular Stabilization) training protocol, alongside conventional treatments, resulted in a significant reduction in pain. One possible explanation for this effect is that the DNS approach simultaneously targets core muscles and respiratory muscles, distinguishing it from other exercise methods and potentially contributing to its efficacy. DNS exercises not only rehabilitate the muscles but also stimulate healthy central motor patterns. Through this process, the nervous system reorganizes and corrects dysfunctional motor patterns, which may lead to more lasting effects compared to non-exercise-based interventions, ultimately improving conditions such as sciatica.

Furthermore, the study revealed that the SMT (Sensorimotor Training) protocol also significantly enhanced trunk endurance. This suggests that sensorimotor training can serve as an ideal intervention for retraining motor response timing and improving control of the motor system, thereby reducing the risk of re-injury. These exercises enhance reflexive activation of the motor system, dynamic stability by improving voluntary motor control and limiting unwanted movements, as well as postural control and coordination of the muscular system. Sensorimotor training is based on adapting proprioceptive receptors to detect high-risk positions and transmit appropriate sensory input to the central nervous system, facilitating the development of safe and effective motor strategies.

Considering the results and participants' conditions, it can be concluded that the DNS group showed greater post-test improvements in sciatic pain, range of motion, and dynamic balance compared to the SMT group. In contrast, the SMT group demonstrated more pronounced improvements in functional disability, proprioception, and trunk endurance. Both training protocols can thus be effective in rehabilitation and improving the condition of individuals with sciatic nerve pain.

Declarations

Ethical Considerations

Compliance with ethical guidelines

This research has an ethics code number (IR.IAU.KHUISF.REC.1403.150) from Islamic Azad University, Isfahan Branch (Khorasgan).

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Authors' contributions

Conceptualization, data collection, analysis, and original draft writing were performed by Bahareh Rahmanian.

Supervision, methodology consultation, project administration, and critical revision of the manuscript were conducted by Hooman Fattahi.

Conflicts of interest

The authors declare that they have no competing interests.

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