



COMPARATIVE EFFICACY OF METHYLPREDNISOLONE ACETATE, DEXAMETHASONE, AND 5% DEXTROSE VIA CAUDAL EPIDURAL INJECTION IN PATIENTS WITH LUMBOSACRAL RADICULAR PAIN: A RANDOMIZED PARALLEL GROUP TRIAL

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ABSTRACT

To compare the effectiveness of methylprednisolone acetate (MPA), dexamethasone (DEXA), and 5% dextrose (D5W) administered through caudal epidural injection for lumbosacral radicular pain. In this randomized trial, 180 adults were allocated equally to receive MPA (80 mg), DEXA (8 mg), or D5W (20 mL). Pain intensity and functional disability were assessed using the Visual Analogue Scale (VAS) and Modified Oswestry Disability Index (ODI) at baseline, 6 weeks, and 12 weeks. Significant follow-up $\times$ intervention interactions were observed for both VAS and ODI ($p < .001$). All groups improved over time; however, MPA and DEXA produced greater and more sustained improvements than D5W. No significant differences were observed between MPA and DEXA. MPA and DEXA demonstrated sustained improvements in pain and disability over 12 weeks, whereas D5W provided less sustained benefit.

KEYWORDS

Lumbosacral Radiculopathy, Caudal Epidural Injection, Methylprednisolone, Dexamethasone, Dextrose

INTRODUCTION

Low back pain (LBP) and lumbosacral radicular pain are major causes of disability, reduced functional independence, and impaired quality of life. The lifetime prevalence of LBP has been estimated at 50%–80%, and low back disorders represent a substantial global burden of disability (Fatoye et al., 2019; Vos et al., 2012). Chronic spinal pain is also associated with considerable healthcare utilization and work-related absenteeism (Herman et al., 2019). Lumbosacral radiculopathy occurs when a lumbar or sacral nerve root is irritated or compressed and is typically characterized by radiating, dermatomal pain, sensory disturbances, motor weakness, or altered reflexes (Tarulli & Raynor, 2007). Radicular symptoms are estimated to occur in approximately 12%–40% of individuals with LBP (Hoy et al., 2010).

Although mechanical nerve-root compression caused by disc herniation or spinal stenosis has traditionally been considered the principal mechanism, inflammatory processes also contribute substantially to radicular pain. Inflammatory mediators, including phospholipase A2, tumor necrosis factor- α , and interleukins, may produce chemical neuritis and persistent symptoms independently of the degree of mechanical compression (Prasad et al., 2005). Abnormal spinal imaging may also occur in individuals without symptoms, emphasizing the importance of inflammatory and clinical factors in the presentation of radicular pain (Boden et al., 1990; Boos et al., 1995).

Conservative management, including pharmacological treatment, physiotherapy, and activity modification, remains the initial approach for most patients. However, caudal epidural steroid injections may be considered when symptoms persist despite conservative treatment (Thoomes et al., 2022; Abdi et al., 2007). Corticosteroids used for epidural injections include particulate agents such as methylprednisolone acetate (MPA) and non-particulate agents such as dexamethasone (DEXA). Although both have demonstrated clinical effectiveness, their physicochemical properties differ, with non-particulate dexamethasone generally considered to have a lower risk of particulate-related vascular complications (Donohue et al., 2020; Rajkumari et al., 2021; Chatterjee et al., 2019).

5% dextrose water (D5W) has more recently been investigated as a non-steroidal option for neuropathic and musculoskeletal pain. Its proposed analgesic effects include modulation of transient receptor potential vanilloid-1 channels and reduction of neurogenic inflammation (Maniquis-Smigel et al., 2016, 2018). Preliminary studies have reported short-term improvements following caudal D5W injections, although evidence directly comparing D5W with corticosteroid injections remains limited (Pandey et al., 2021).

Therefore, this study compared MPA, DEXA, and D5W administered

through caudal epidural injection for lumbosacral radicular pain. The primary outcome was pain intensity measured using the Visual Analogue Scale (VAS), while functional disability was assessed using the Modified Oswestry Disability Index (ODI).

METHODS

Study Design and Setting

This study was a single-blind, randomized, parallel-group interventional trial conducted at the Rehabilitation Research Centre, Department of Physical Medicine and Rehabilitation, Sawai Man Singh Medical College and Hospital, Jaipur, India, between November 2023 and September 2024. Participants were randomly allocated to receive a single caudal epidural injection of MPA, DEXA, or D5W. The study was conducted in accordance with the Declaration of Helsinki and CONSORT recommendations. Ethical approval was obtained from the institutional Ethics Committee (approval no. 470/MC/EC/2023; dated April 26, 2023), and written informed consent was obtained from all participants before enrolment. The study was prospectively registered with the Clinical Trials Registry of India.

Participants and Sample Size

Adults aged 18–70 years with clinically diagnosed lumbosacral radicular pain were considered eligible. Diagnosis was based on radiating pain corresponding to a dermatomal distribution and at least one positive neural tension sign, including the straight-leg-raise, crossed straight-leg-raise, Bragard, or femoral-stretch test. Patients were excluded if they had cauda equina syndrome, severe paresis, previous spinal surgery or epidural injection, congenital spinal deformity, spinal trauma, inflammatory or infectious spinal pathology, diabetes mellitus, anticoagulation therapy, cognitive impairment, psychiatric illness, or pregnancy/lactation.

An a priori sample-size calculation was performed using G*Power. The analysis was based on repeated-measures ANOVA for a within-between interaction involving three intervention groups and three measurements, with $\alpha = .05$, nonsphericity correction = 1, correlation among repeated measures = .50, power = .90, and an effect size of $f = .15$. The estimated minimum sample was 39 participants per group. Accordingly, 180 participants were recruited, with 60 participants assigned to each intervention group.

Randomization and Blinding

Participants were randomly assigned in a 1:1:1 ratio to the MPA, DEXA, or D5W groups using an online randomization tool. Randomization was performed by a statistician who was independent of participant recruitment. Participants were blinded to their treatment

allocation, whereas the physician administering the injection could not be blinded because of differences in drug preparation. Outcome assessors remained blinded to group allocation.

Intervention

Each participant received a single caudal epidural injection with a total volume of 20 mL. The MPA group received 80 mg methylprednisolone acetate (2 mL) diluted with 18 mL normal saline. The DEXA group received 8 mg dexamethasone sodium phosphate (2 mL) diluted with 18 mL normal saline. The D5W group received 20 mL of 5% dextrose solution. All procedures were performed under aseptic conditions using an anatomical landmark-guided caudal approach. Participants were positioned prone, and the sacral hiatus was identified by palpation. A 22-gauge needle was introduced through the sacrococcygeal ligament into the epidural space, followed by confirmation using the described "hoosh test." After negative aspiration for blood or cerebrospinal fluid, the allocated solution was injected slowly.

Outcome Measures and Data Collection

Baseline demographic, clinical, and examination data were recorded at enrollment. Pain intensity was the primary outcome and was assessed using the Visual Analogue Scale (VAS). Functional disability was the secondary outcome and was assessed using the Modified Oswestry Disability Index (ODI). Both outcomes were measured at baseline (Week 0), 6 weeks, and 12 weeks after intervention. Participants subsequently received a standardized post-injection rehabilitation protocol, including oral cefixime 200 mg twice daily for 5 days and supervised flexion-regimen exercises beginning 4 days after the procedure.

Statistical Analysis

Data normality was assessed using the Shapiro-Wilk test. Continuous variables were presented as mean $\pm$ standard deviation, while categorical variables were summarized as frequencies and percentages. A 3×3 mixed repeated-measures ANOVA was performed, with follow-up time (Week 0, Week 6, and Week 12) as the within-subject factor and intervention group (MPA, DEXA, and D5W) as the between-subject factor. Significant interaction effects were followed by within-group repeated-measures ANOVA and between-group one-way ANOVA. Least Significant Difference post hoc testing was used for pairwise comparisons. Statistical significance was set at $p \leq .05$. Analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS

A total of 180 participants completed the study, with 60 participants allocated to each intervention group (MPA, DEXA, and D5W). Baseline demographic and clinical characteristics were comparable among the groups, with no significant differences in the assessed variables ($p = .134-.979$) (Table 1).

Variable	MPA Group (n=60)	DEXA Group (n=60)	D5W Group (n=60)	p-value
Age (mean $\pm$ SD)	42.5 $\pm$ 11.7	41.3 $\pm$ 12.5	42.0 $\pm$ 13.7	0.979a
Gender – Male : Female (%)	51.7 : 48.3	76.7 : 23.3	36.7 : 63.3	0.240b
Education $\leq$ High school	51.7	58.3	60.0	0.273b
Diet – Mixed : Pure veg (%)	91.7 : 8.3	85 : 15	85 : 15	0.450b
Residence – Rural : Urban (%)	35.0 : 65.0	48.3 : 51.7	53.3 : 46.7	0.110b
Religion – Hindu (%)	75	80	70	0.552b
Pain duration >12 wks (%)	30.0	20.0	40.0	0.175b

a. One-way ANOVA
b. Chi-square test

A significant follow-up $\times$ intervention interaction was observed for both VAS and ODI scores ($p < .001$), indicating that changes over time differed among the three interventions (Figures 1 and 2). VAS scores improved significantly within all groups over 12 weeks ($p < .001$). At Weeks 6 and 12, both MPA and DEXA produced significantly greater pain reduction than D5W ($p < .001-.040$), whereas no significant difference was observed between MPA and DEXA. D5W showed a significant increase in VAS between Weeks 6 and 12 ($p = .005$) (Table 2).

Table 2: Comparison of VAS score at Week 0, Week 6, and Week 12 between MPA, DEXA and D5W intervention.

Follow-up	Intervention (Mean $\pm$ SD)			Main Effect (intervention) p-value ^a
	MPA	DEXA	D5W	
Week 0	7.03 $\pm$ 1.34	7.07 $\pm$ 1.21	6.64 $\pm$ 1.12	0.132
Week 6	3.78 $\pm$ 1.75* $\ddagger$	4.22 $\pm$ 1.53* $\ddagger$	4.80 $\pm$ 1.34*	< 0.001
Week 12	3.56 $\pm$ 1.84* $\ddagger$	3.62 $\pm$ 1.73* $\ddagger$	5.53 $\pm$ 1.53* $\ddagger$	< 0.001
Main Effect (Follow-up) p-value ^b	< 0.001	< 0.001	< 0.001	

a – One-way ANOVA, b – Repeated measures ANOVA, * – significantly different from week 0, $\ddagger$ – significantly different from week 6, $\ddagger$ – significantly different from D5W, VAS – Visual Analogue Scale, MPA – Methylprednisolone Acetate, DEXA – Dexamethasone Sodium Phosphate, D5W – Dextrose Solution, SD – Standard Deviation.

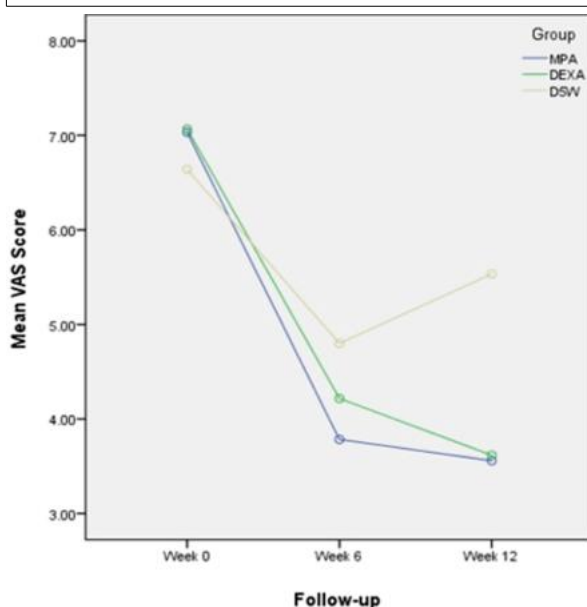


Figure 1. Comparison of Visual Analogue Scale Score for Pain at Different Follow-Ups Between Different Interventions. MPA – Methylprednisolone Acetate, DEXA – Dexamethasone Sodium Phosphate, D5W – Dextrose Solution, VAS – Visual Analogue Scale.

ODI scores also improved significantly in all groups ($p < .001$). At Week 6, MPA showed greater functional improvement than D5W ($p = .003$). At Week 12, both MPA and DEXA demonstrated significantly better ODI scores than D5W ($p < .001$), with no significant difference between the corticosteroid groups. No major adverse events were reported; minor transient injection-site soreness and dizziness resolved spontaneously (Table 3).

Table 3: Comparison of ODI score at Week 0, Week 6, and Week 12 between MPA, DEXA and D5W intervention.

Follow-up	Intervention (Mean $\pm$ SD)			Main Effect (intervention) p-value ^a
	MPA	DEXA	D5W	
Week 0	25.0 $\pm$ 6.9	28.9 $\pm$ 7.4 $\ddagger$	27.7 $\pm$ 7.7 $\ddagger$	0.014
Week 6	20.7 $\pm$ 5.5*	22.1 $\pm$ 6.0*	24.1 $\pm$ 6.4* $\ddagger$	0.011
Week 12	20.6 $\pm$ 5.1*	20.6 $\pm$ 6.4* $\ddagger$	25.5 $\pm$ 5.3* $\ddagger$ $\S$	< 0.001
Main Effect (Follow-up) p-value ^b	< 0.001	< 0.001	< 0.001	

a – One-way ANOVA, b – Repeated measures ANOVA, * – significantly different from week 0, $\ddagger$ – significantly different from week 6, $\ddagger$ – significantly different from MPA, $\S$ – significantly different from DEXA, ODI – modified Oswestry disability index, MPA – Methylprednisolone Acetate, DEXA – Dexamethasone Sodium Phosphate, D5W – Dextrose Solution, SD – Standard Deviation.

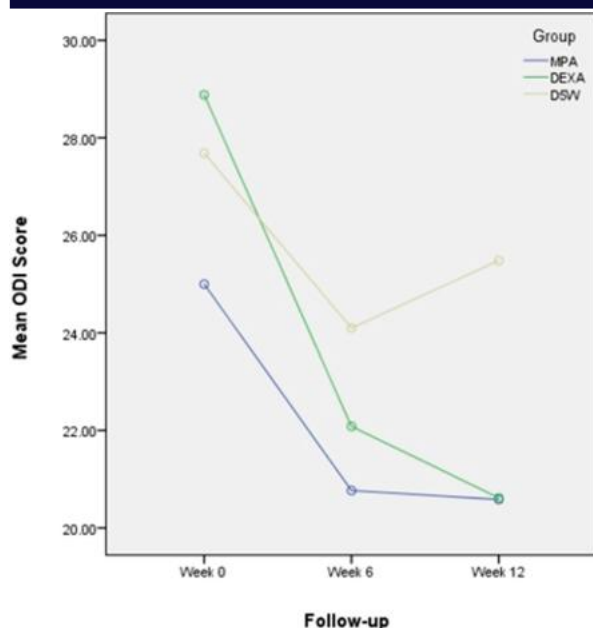


Figure 2. Comparison of Modified Oswestry Disability Index for Functional Disability at Different Follow-ups Between Different Interventions. MPA – Methylprednisolone Acetate, DEXA – Dexamethasone Sodium Phosphate, D5W – Dextrose Solution, ODI – Modified Oswestry Disability Index.

DISCUSSION

This randomized parallel-group trial compared the effects of MPA, DEXA, and 5% D5W administered by caudal epidural injection in patients with lumbosacral radicular pain. The principal finding was that both corticosteroid interventions produced significant and sustained improvements in pain intensity and functional disability over 12 weeks. Although D5W also produced an initial improvement, its effect was less sustained, with an increase in pain by Week 12. These findings indicate that the three interventions did not produce equivalent trajectories of recovery over the study period.

MPA produced a marked reduction in VAS scores during the first 6 weeks, followed by a relatively small additional improvement between Weeks 6 and 12. This pattern may indicate that the principal analgesic benefit of MPA occurred during the early follow-up period. Similar improvements following particulate corticosteroid injections have been reported in previous studies (Nazir et al., 2021; Hamid et al., 2020). In contrast, DEXA demonstrated a more progressive reduction in pain across both follow-up intervals. Previous investigations have similarly reported clinically meaningful pain reduction following epidural dexamethasone administration (Denis et al., 2015; Shahien et al., 2022; Kennedy et al., 2014; Ahadian et al., 2011).

The absence of a significant difference between MPA and DEXA at 12 weeks is consistent with previous comparative research. Donohue et al. (2020) reported comparable pain and functional outcomes following methylprednisolone and dexamethasone epidural injections. Similarly, Rajkumari et al. (2021) found comparable improvements in VAS and ODI scores between the two corticosteroids, while Chatterjee et al. (2019) reported satisfactory short-term outcomes with both agents. The present findings therefore support the observation that particulate and non-particulate corticosteroids can provide comparable clinical improvement over the short- to mid-term. However, the 12-week follow-up does not establish whether these effects remain comparable over longer periods.

D5W demonstrated a different response pattern. Pain improved substantially by Week 6 but partially returned by Week 12. This finding is broadly consistent with previous research showing short-term analgesic effects following epidural D5W administration (Maniquis-Smigel et al., 2016, 2018). Pandey et al. (2021) reported benefit over approximately three months when repeated D5W injections were used, suggesting that treatment frequency may influence the durability of its effects. K roglu et al. (2019) likewise reported initial improvement and suggested that D5W may be considered alongside physical therapy.

The differences between D5W and corticosteroids may partly reflect their proposed mechanisms of action. Corticosteroids exert potent anti-inflammatory effects, whereas D5W has been proposed to produce analgesia through neuromodulatory mechanisms involving transient receptor potential vanilloid-1 (TRPV1) channels and dorsal-root-ganglion activity (Maniquis-Smigel et al., 2016). These mechanisms may explain the early analgesic response but do not necessarily provide the same prolonged anti-inflammatory effect as corticosteroids. Evidence from repeated D5W administration suggests that it may nevertheless have a role in longer-term treatment strategies when used serially rather than as a single injection (Maniquis-Smigel et al., 2018).

No major adverse events were observed in any intervention group, consistent with previous reports concerning dexamethasone and D5W injections (Donohue et al., 2020; Rajkumari et al., 2021; Pandey et al., 2021; Maniquis-Smigel et al., 2018). However, several limitations should be considered. Follow-up was restricted to 12 weeks, preventing assessment of long-term effectiveness and recurrence. Exclusion of patients with diabetes and other comorbidities limits generalizability. Landmark-guided rather than fluoroscopy-guided injection may have introduced variability in drug placement. Finally, VAS and ODI are subjective measures and may be influenced by recall and psychosocial factors. Future studies should include longer follow-up, objective outcomes, image-guided procedures, and broader patient populations.

CONCLUSIONS

Both MPA and DEXA administered through caudal epidural injection produced significant and sustained reductions in pain and functional disability over 12 weeks in patients with lumbosacral radicular pain. Their clinical effects were comparable. Although 5% dextrose also improved outcomes initially, its analgesic effect was less sustained at 12 weeks. These findings support corticosteroid-based caudal epidural injections as effective short- to mid-term interventions, while further research is needed to establish the long-term role of D5W.

REFERENCES

- Abdi, S., Datta, S., Trescot, A. M., Schultz, D. M., Adlaka, R., Atluri, S. L., & Smith, H. S. (2007). Epidural steroids in the management of chronic spinal pain: A systematic review. *Pain Physician*, 10, 185–212.
- Ahadian, F. M., McGreevy, K., & Schulte, G. (2011). Lumbar transforaminal epidural dexamethasone: A prospective, randomized, double-blind, dose-response trial. *Regional Anesthesia and Pain Medicine*, 36(6), 572–578.
- Boden, S. D., Davis, D. O., Dina, T. S., Patronas, N. J., & Wiesel, S. W. (1990). Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects: A prospective investigation. *The Journal of Bone and Joint Surgery. American Volume*, 72(3), 403–408.
- Boos, N., Rieder, R., Schade, V., Spratt, K. F., Semmer, N., & Aebi, M. (1995). 1995 Volvo Award in clinical sciences: The diagnostic accuracy of magnetic resonance imaging, work perception, and psychosocial factors in identifying symptomatic disc herniations. *Spine*, 20, 2613–2625.
- Chatterjee, N., Roy, C., Das, S., Al Ajmi, W., Al Sharji, N. S., & Al Mandhari, A. (2019). Comparative efficacy of methylprednisolone acetate and dexamethasone disodium phosphate in lumbosacral transforaminal epidural steroid injections. *Turkish Journal of Anaesthesiology and Reanimation*, 47(5), 414–419.
- Denis, I., Claveau, G., Filiatrault, M., Fug re, F., & Fortin, L. (2015). Randomized double-blind controlled trial comparing the effectiveness of lumbar transforaminal epidural injections of particulate and nonparticulate corticosteroids for lumbosacral radicular pain. *Pain Medicine*, 16(9), 1697–1708.
- Donohue, N. K., Tarima, S. S., Durand, M. J., & Wu, H. (2020). Comparing pain relief and functional improvement between methylprednisolone and dexamethasone lumbosacral transforaminal epidural steroid injections: A self-controlled study. *The Korean Journal of Pain*, 33(2), 192–198.
- Fatoye, F., Gebrye, T., & Odeyemi, I. (2019). Real-world incidence and prevalence of low back pain using routinely collected data. *Rheumatology International*, 39, 619–626.
- Hamid, M. B. A., Dar, A. R., & Rashid, N. (2020). Comparison of methylprednisolone and dexamethasone for transforaminal epidural steroid injections in lumbar disc disease. *Journal of Medical Science and Clinical Research*, 8(6).
- Herman, P. M., Broten, N., Lavelle, T. A., Sorbero, M. E., & Coulter, I. D. (2019). Health care costs and opioid use associated with high-impact chronic spinal pain in the United States. *Spine*, 44(16), 1154–1161.
- Hoy, D., Brooks, P., Blyth, F., & Buchbinder, R. (2010). The epidemiology of low back pain. *Best Practice & Research Clinical Rheumatology*, 24(6), 769–781.
- Kennedy, D. J., Noh, M. Y. (2011). The role of core stabilization in lumbosacral radiculopathy. *Physical Medicine and Rehabilitation Clinics of North America*, 22(1), 91–103.
- Kennedy, D. J., Plastaras, C., Casey, E., Visco, C. J., Rittenberg, J. D., & Conrad, B. (2014). Comparative effectiveness of lumbar transforaminal epidural steroid injections with particulate versus nonparticulate corticosteroids for lumbar radicular pain due to intervertebral disc herniation: A prospective, randomized, double-blind trial. *Pain Medicine*, 15(4), 548–555.
- K roglu,  .,  rselik, A., Karasimav,  ., Demir, Y., & Solmaz,  . (2019). Is 5% dextrose prolotherapy effective for radicular low back pain? *G lhane Medical Journal*, 61(3), 123.
- Maniquis-Smigel, L., Reeves, K. D., Rosen, H. J., Lyftogt, J., Coleman, C. G., & Cheng, A. L. (2016). Short-term analgesic effects of 5% dextrose epidural injections for chronic low back pain: A randomized controlled trial. *Anesthesiology and Pain Medicine*, 7(1).
- Maniquis-Smigel, L., Reeves, K. D., Rosen, H. J., Lyftogt, J., Graham-Coleman, C., & Cheng, A. L. (2018). Analgesic effect and potential cumulative benefit from caudal epidural D5W in consecutive participants with chronic low-back and buttock/leg pain. *Journal of Alternative and Complementary Medicine*, 24(12), 1189–1196.

17. Nazir, N., Gupta, S., & Saxena, V. (2021). Randomized controlled trial comparing the efficacy and safety of epidural infiltration of particulate versus nonparticulate steroids in the treatment of patients with sciatic pain. *International Journal of Innovative Research in Medical Sciences*, 6(12), 911–914.
18. Pandey, N., Nayak, P., & Gahnlolia, V. (2021). A randomized control trial on efficacy of analgesic effect of 5% dextrose caudal epidural injection for non-specific chronic low back pain. *International Journal of Science and Research*, 11, 1–3.
19. Prasad, R., Hoda, M., Dhakal, M., Singh, K., Srivastava, A., & Sharma, V. (2005). Epidemiological characteristics of lumbar disc prolapse in a tertiary care hospital. *The Internet Journal of Neurosurgery*, 3(1), 1–5.
20. Rajkumari, K., Singh, A., Singh, L., Chabungbam, M., Sreejith, C., & Janet, M. (2021). Transforaminal epidural injection of dexamethasone vs methylprednisolone in reducing low back pain and disability in prolapsed lumbar intervertebral disc in Manipur, India: A randomized controlled trial. *Journal of Clinical and Diagnostic Research*.
21. Shahien, R., Wiegler, K., Dekel, L., Sharabi-Nov, A., & Saleh, S. (2022). Retrospective study assessing the efficacy of intravenous dexamethasone, SNB, and nonsteroidal treatment for radiculopathy. *Medicine*, 101(28).
22. Tarulli, A. W., & Raynor, E. M. (2007). Lumbosacral radiculopathy. *Neurologic Clinics*, 25(2), 387–405.
23. Thoomes, E., Falla, D., Cleland, J. A., Fernández-de-las-Peñas, C., Gallina, A., & de Graaf, M. (2022). Conservative management for lumbar radiculopathy based on the stage of the disorder: A Delphi study. *Disability and Rehabilitation*, 45(21), 3539–3548.
24. Vos, T., Flaxman, A. D., Naghavi, M., Lozano, R., Michaud, C., Ezzati, M., Shibuya, K., Salomon, J. A., Abdalla, S., Aboyans, V., Abraham, J., Ackerman, I., Aggarwal, R., Ahn, S. Y., Ali, M. K., Alvarado, M., Anderson, H. R., Anderson, L. M., Andrews, K. G., ... Murray, C. J. L. (2012). Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: A systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*, 380(9859), 2163–2196.