

Manual Therapy in Cervical/Lumbar Radiculopathy

Subjects: **Health Care Sciences & Services**

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A comprehensive literature review was conducted using PubMed and Web of Science databases up to April 2020. The following inclusion criteria were used: (1) presence of radiculopathy; (2) treatment defined as manual therapy (i.e., traction, manipulation, mobilization); and (3) publication defined as a Randomized Controlled Trial. The electronic literature search resulted in 473 potentially relevant articles. Finally, 27 articles were accepted: 21 on cervical (CR) and 6 in lumbar radiculopathy (LR). The mean PEDro score for CR was 6.6 (SD 1.3), and for LR 6.7 (SD 1.6). Traction-oriented techniques are the most frequently chosen treatment form for CR and are efficient in reducing pain and improving functional outcomes. In LR, each of the included publications used a different form of manual therapy, which makes it challenging to summarize knowledge in this group. Of included publications, 93% were either of moderate or low quality, which indicates that quality improvement is necessary for this type of research.

manual therapy

low back pain

neck pain

radiculopathy

spine

1. Introduction

Radiculopathy is described as nerve root irritation resulting from various pathologies, including herniated intervertebral disc (22% cases), bone spurs, spinal instability, and trauma [1][2]. Upper and lower limb pain can be referred to as the main symptom of cervical or lumbar pathology. Other symptoms usually include muscle weakness, local pain, motor, sensory, or reflex deficits [3][4].

Cervical radiculopathy (CR) is most prevalent in individuals over 40 years of age, with an annual incidence of 83.2 per 100,000 persons [5]. This makes it less common than lumbar radiculopathy (LR) [3] (also known as sciatica), whose prevalence has been documented in the USA as high as 25% of all lower back pain (LBP) cases [6] and represents the most common complaint among patients visiting a spine surgeon [7][8]. Due to its severe manifestation and the lack of treatment standardization, irrespective of healthcare system type, radiculopathy causes substantial socio-economic problems and limits daily living activities due to disability and inability to work that can last up to 20 weeks after surgical treatment [9][10][11].

Referred symptoms, including pain, cause more significant disability when compared to local pain alone [12]. Although radiculopathy remains a challenge for both researchers and clinicians, various non-operative forms of treatment are used to improve patients' outcomes. The successful treatment method is non-surgical in 75%–90% of cases suffering from cervical radiculopathy (CR) [13][14][15]. In recent years, studies have shown the effectiveness

of physical therapy involving strengthening or stretching, and also various forms of manipulative therapy for radiculopathy [1][16][17][18].

Manual therapy forms can be joint-oriented (mobilization, manipulation, traction), soft-tissue-oriented (massage forms), neural-tissue-oriented (neurodynamic), or mixed (specific exercises). Most of these treatments are successful in improving radiculopathy symptoms [19][20], but the quality of evidence might often be questioned. There is still only low-level evidence that neural mobilizations can be successful as a standalone method [21]. Little is known about joint mobilization efficacy alone in treating radiculopathy. While its biomechanical background remains unclear [22], one of the most commonly used manual therapy methods is traction, but evidence on its efficacy, whether applied alone or combined, needs further research [23][24]. While numerous CR reviews can be found in the literature in recent years [5][22][25][26][27][28][29], those regarding the lumbar region are minimal [7][9][27] and often of poor quality [30]. The latest reviews regarding CR and LR come from 2016 [5] and 2017 [30] respectively, which was encouraging.

2. Cervical Radiculopathy

Treatment with CR, unlike LR, mainly focused on traction techniques in most authors. This situation is due mainly to a much more comfortable grip and control in the cervical spine than in the lumbar spine, which is a more specific technique. While Ayub et al. (2019) combined traction with other treatment forms such as neural mobilization (passive vs. active), none of the treatment methods was found to be superior to the others [31]. Afzal et al. (2019) also compared manual traction, manual opening techniques, and a combination of these in patients with CR, but the effects of both techniques were equally effective in functional outcome [32]. Traction stood as baseline technique in many studies, and none of them showed superiority while used alone. This type of technique can be varied in specifying starting position, direction, force, amplitude, and velocity. In the gathered literature, there is a lack of detail on manual traction attributes. In most cases, this should be considered as general traction. For instance, Jellad et al. (2009) detailed it as intermittent traction, but no further information was provided [33]. Fritz et al. (2014) also used different forms of non-specific, mechanical traction combined with an exercise program that confirmed its efficacy and superiority to exercises alone, but no “traction alone” subgroup was formed [34]. Although most authors observed improvement in patients’ functional outcomes using traction or a traction component in a multimodal approach, some did not find that adding traction was successful in treating CR [35]. Shafique et al. (2019) also proved that multimodal treatment could provide better effects in patients with cervical radiculopathy [36]. This was based on spinal mobilizations, neuro-dynamics and arm movements. Cervical radiculopathy, thought to be mechanical, spatial dysfunction, also needs treatment, including movement, both proximally and distally. It has to be mentioned that a small number of papers used clinical tests for assessing functional outcomes [31][37][38][39]. This is because local pain is not the primary CR and LR problem, but distal dysfunction (e.g., muscle weakness, motor and sensory deficits due to neural malfunction), causing disability, which should always be assessed. LR also lacks in this regard, and three authors chose that way of assessing patients which, on the other hand, was more than half of all LR literature [40][41][42]. Wainner et al. (2003) proved that, for cervical radiculopathy, the ULNT tests, and especially the 1A type, are most useful for ruling out this pathology [43].

Neural mobilization is a type of technique aimed at healing neural tissue which is considered to be one of the main problems in radiculopathy after mechanical compression [44]. Nerve root will become impeded when is overstretched, or its blood supply is limited due to compression for a significantly long time, or both. Some authors applied neural mobilization techniques as a treatment for CR [31]. While Ayub et al. (2019) tried to prove the different effects comparing active and passive form of this technique in a multimodal approach, Kim et al. (2017) applied neural mobilization, different to the multimodal approach, but not using traction alone. In both cases, the effects were positive on functional outcomes [31][37], although the former author included only females, which may limit the generalizability of the results. So far, the question of neural mobilization techniques' efficacy in CR remains unsolved.

Joint techniques are appropriate in treating joint-oriented dysfunction. This type of impairment can be taken into consideration regarding the biomechanical background of CR and LR. The relation of facet joints may be imbalanced, which can result in joint(s)' hyper- or hypomobility. These techniques are aimed at treating hypomobile segments, while the hypermobile needs to be stabilized by in-depth muscle training. No author provides details on patients' manual examination, called "joint play" in manual therapy, which is essential in stating whether this individual needs to be mobilized in this segment in this particular direction. Although Ayub et al. (2019) and Bukhari et al. (2016) applied mobilization in their research, it was only part of a multimodal approach aiming to differentiate traction techniques, with no further details provided on mobilized segment [31][45]. Young et al. (2019) mentioned manual therapy, but they focused mainly on thoracic spine thrust and non-thrust manipulations and unspecified neck movements without further details on a specific segment [35]. A different manipulation-oriented approach was proposed by Yang et al. (2016) based on patients' radiographs—the group age range was high (55–75), but the effects of the manipulation were promising [46]. As well as age, inclusion criteria specified CSR (cervical spondylotic radiculopathy).

A specific exercise program has been used by several authors [45][47][34][33][35][39]. Only two authors aimed the exercise form at the biomechanical aspect of CR's etiology, which was to increase the size of the intervertebral foramen, and no significant, positive results were observed [32][47]. Unfortunately, the authors did not provide any further details on the exercise program, besides an isometric strengthening of the muscles. Fritz et al. (2014) used a neck exercise program as a base for each of three formed groups (G1: exercise, G2: exercise + mechanical traction, G3: exercise + over-door traction) which resulted in reducing the level of neck and arm pain. The exercise program for neck included supine crano-cervical flexion to activate deep stabilizing muscles with an air-filled pressure sensor as feedback. In contrast, scapular-strengthening exercises included prone horizontal abduction, side-lying forward flexion, prone extensions and push-ups [34]. Jellad et al. (2009) applied a "standard" rehabilitation program including ultrasound, infrared, massage, cervical spine mobilizations, and isometric muscle strengthening. No details on the above activities, such as dozing, area, direction, etc., were found, so it cannot be considered as a specific treatment method despite the fact of its efficacy in improving pain and functional outcome [33]. Young et al. (2019) proved that the the exercise program, including cervical retractions, extensions, and deep flexors' activation, was efficient with or without adding an extra traction component. Although they described the details of every maneuver, we found no information on which specific exercise was used in each session, so it is impossible to state whether the program was consistent and repeatable [48]. Joghataei et al. (2004) used exercises

including neck deep flexor strengthening as a base which showed an improvement, but significant relief was observed after adding cervical traction combined with electrotherapy [39]. Akkan et al. (2018) also proved that stabilizing exercises including of the deep neck muscles, can improve pain, quality of life and patients' posture [49]. Wibault et al. (2017) observed promising effects using neck-specific exercises compared to the standard approach in patients who had undergone surgical treatment [50]. A similar outcome was observed by other researchers when comparing neck-specific training with a prescribed standard physical activity approach [51][52].

3. Lumbar Radiculopathy

Regarding LR, a limited number of RCTs was found to be eligible in this review. Among the five studies, few methods of treatment for LR were used by authors, and, unlike CR, no trends in choosing treatment form were observed. No unity was found in functional outcome assessment across all included studies. Only two of five studies included neurodynamic tests (SLR) [40][41]. Moustafa et al. (2013) applied a lumbar lordotic angle as an outcome, but this parameter was also an inclusion criterion [42]. Although all authors used questionnaires as an outcome, two of them decided to include only this type of examination, which makes it difficult to answer the question on individuals' clinical improvement, as they had omitted this part.

Due to the diversity of treatment methods used, it is challenging to compare their effects. Satpute et al. (2019) applied spinal mobilizations with leg movement plus exercise and electrotherapy, compared to exercise and electrotherapy alone [40] and found significantly improved outcomes, especially in mobilization. The adjacent segments mobilization might also be helpful for LR patients and was proved by Kostadinović et al. (2020) in their studies [53]. They applied thoracic spine mobilization and lumbar stabilization. This type of approach is focused on improving hypomobile segments' motion in the thoraco-lumbar region to reduce axial forces in lumbar segments. On the other hand, McMorland et al. (2010) compared surgical treatment (microdiscectomy) and standardized spinal manipulation by a chiropractor in patients who had not responded to other non-specific forms of non-operative treatment for at least three months. Both methods significantly improved the patient's functional outcome and pain level. Unfortunately, no clinical examination was applied in the study, such as SLR, SLUMP, or other neurodynamic forms (e.g., EMG) [54]. Due to the different study project, joint-oriented, but with differently aimed techniques (mobilization vs. manipulation), we found it difficult to compare these two authors' works to each other. Surgical treatment should be considered only along with the red-flag-symptoms that occurred. Another study that used the manipulation approach was that of Ghasabmahaleh et al. (2020). They observed patients' outcomes improvements in subacute and chronic LR using Maigne's techniques [55]. The group that underwent physiotherapy and manipulations had superior results to physiotherapy alone. Different approaches including epidural injection with manipulation were proposed by Yin et al. (2018). They observed better effects in the multimodal approach group; however, one of their methods was invasive [56].

Exercise programs are present in two out of five (40%) of our findings [40][57]. Gudavalli et al. (2006) compared the active trunk exercise program (ATEP) which is based on activation of deep, lumbar stabilizing muscles with flexion-distraction maneuver (FD). ATEP was found to be significantly more effective in the recurrent pain group with moderate to severe symptoms, while FD was better for chronic symptoms (defined by the author as pain lasting

longer than three months) [57]. The first author also found the exercise program to be effective. However, the aim of the study was to prove the efficacy of a multimodal approach, rather than exercise alone [40].

When analyzing the efficacy of neural tissue mobilization, two authors applied this type of treatment [44][41]. Despite the promising conclusion of improvement in SLR and VAS outcome, Tambekar et al. (2016) did not observe a significant effect maintained in the follow-up stage [41]. The quality of this study was also limited due to the absence of concealed allocation, no blinding, no adequate follow-up, and no intention-to-treat analysis. Plaza-Manzano et al. (2019) did not find neurodynamic mobilization to be effective when combined with motor control training compared to motor control training alone [44]. However, it should be mentioned that inclusion criteria included an extensive range of participants' age (18–60) and SLR score was considered to be eligible when the pain was reproduced only within 40–70 degrees of range.

4. Methodological Concerns

The overall quality of the included studies' is low to moderate. Only one study designed an intervention with blind therapists [44], and two other studies designed the research with blind participants [48][47]. This is due to the specificity of treatment techniques thought to apply a biomechanical result in a specific area. In this type of intervention, blinding the therapist or physician is difficult to do, and in some cases impossible. Therefore, we treated the 'blinding the therapist' criterion with caution.

5. Future Directions

The main recommendations relate to the standardization of clinical examination with objective methods or specific devices and full details on the intervention. The decision-making process would be more fruitful with advanced radiological imaging and functional outcome extended by neurodynamic tests that correlate with symptoms in distal parts of the body. As symptomatic radiculopathy most often impairs the extremities' function, it should be essential to focus on this field and control the outcome using clinical tests such as ULNTs for CR and SLR and SLUMP for LR. Insufficiently detailed information is most often found for specific techniques. No detailed pre-intervention assessment is normally provided, which complicates the selection of appropriate treatment.

References

1. Childress, M.A.; Becker, B.A. Nonoperative Management of Cervical Radiculopathy. *Am. Fam. Physician* 2016, 93, 746–754.
2. Beckworth, W.J.; Abramoff, B.A.; Bailey, I.M.; Yoon, S.; Umpierrez, M.; Kakarala, A.; Lee, J.Y.; Ward, L.A.; Dows-Martinez, M.N.; Yoon, S.T. Acute Cervical Radiculopathy Outcomes: Soft Disc Herniations vs Osteophytes. *Pain Med.* 2021, 22, 561–566.

3. Corey, D.L.; Comeau, D. Cervical Radiculopathy. *Med. Clin. N. Am.* 2014, 98, 791–799.
4. Tarulli, A.W.; Raynor, E.M. Lumbosacral Radiculopathy. *Neurol. Clin.* 2007, 25, 387–405.
5. Thoomes, E.J. Effectiveness of Manual Therapy for Cervical Radiculopathy, a Review. *Chiropr. Man. Ther.* 2016, 24, 45.
6. Selkirk, S.M.; Ruff, R. Low Back Pain, Radiculopathy. *Handb. Clin. Neurol.* 2016, 136, 1027–1033.
7. Berry, J.A.; Elia, C.; Saini, H.S.; Miulli, D.E. A Review of Lumbar Radiculopathy, Diagnosis, and Treatment. *Cureus* 2019, 11, e5934.
8. Benoist, M. The Natural History of Lumbar Disc Herniation and Radiculopathy. *Jt. Bone* 2002, 69, 155–160.
9. Huysmans, E.; Goudman, L.; Van Belleghem, G.; De Jaeger, M.; Moens, M.; Nijs, J.; Ickmans, K.; Buyl, R.; Vanroelen, C.; Putman, K. Return to Work Following Surgery for Lumbar Radiculopathy: A Systematic Review. *Spine J.* 2018, 18, 1694–1714.
10. Cohen, S.P. Epidemiology, Diagnosis, and Treatment of Neck Pain. *Mayo Clin. Proc.* 2015, 90, 284–299.
11. Benditz, A.; Loher, M.; Boluki, D.; Grifka, J.; Völlner, F.; Renkawitz, T.; Maderbacher, G.; Götz, J. Positive Medium-Term Influence of Multimodal Pain Management on Socioeconomic Factors and Health Care Utilization in Patients with Lumbar Radiculopathy: A Prospective Study. *J. Pain Res.* 2017, 10, 389–395.
12. Casey, E. Natural History of Radiculopathy. *Phys. Med. Rehabil. Clin. N. Am.* 2011, 22, 1–5.
13. Woods, B.I.; Hilibrand, A.S. Cervical Radiculopathy: Epidemiology, Etiology, Diagnosis, and Treatment. *J. Spinal Disord. Tech.* 2015, 28, 251–259.
14. Yamazaki, S.; Kokubun, S.; Ishii, Y.; Tanaka, Y. Courses of Cervical Disc Herniation Causing Myelopathy or Radiculopathy: An Analysis Based on Computed Tomographic Discograms. *Spine* 2003, 28, 1171–1175.
15. Rhee, J.M.; Yoon, T.; Riew, K.D. Cervical Radiculopathy. *J. Am. Acad. Orthop. Surg.* 2007, 15, 486–494.
16. Ostelo, R.W. Physiotherapy Management of Sciatica. *J. Physiother.* 2020, 66, 83–88.
17. Wang, R.; Weng, L.-M.; Peng, M.-S.; Wang, X.-Q. Exercise for Low Back Pain: A Bibliometric Analysis of Global Research from 1980 to 2018. *J. Rehabil. Med.* 2020, 52, jrm00052.
18. Sheng, Y.; Duan, Z.; Qu, Q.; Chen, W.; Yu, B. Kinesio Taping in Treatment of Chronic Non-Specific Low Back Pain: A Systematic Review and Meta-Analysis. *J. Rehabil. Med.* 2019, 51, 734–740.

19. Pennetti, A. A Multimodal Physical Therapy Approach Utilizing the Maitland Concept in the Management of a Patient with Cervical and Lumbar Radiculitis and Ehlers-Danlos Syndrome-Hypermobility Type: A Case Report. *Physiother. Theory Pract.* 2018, **34**, 559–568.
20. Bilgilisoy Filiz, M.; Kılıç, Z.; Uçkun, A.; Çakır, T.; Koldaş Doğan, Ş.; Toraman, N.F. Mechanical Traction for Lumbar Radicular Pain: Supine or Prone? A Randomized Controlled Trial. *Am. J. Phys. Med. Rehabil.* 2018, **97**, 433–439.
21. Eubanks, J.D. Cervical Radiculopathy: Nonoperative Management of Neck Pain and Radicular Symptoms. *Am. Fam. Physician* 2010, **81**, 33–40.
22. Romeo, A.; Vanti, C.; Boldrini, V.; Ruggeri, M.; Guccione, A.A.; Pillastrini, P.; Bertozzi, L. Cervical Radiculopathy: Effectiveness of Adding Traction to Physical Therapy-A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Phys. Ther.* 2018, **98**, 231–242.
23. Fritz, J.M.; Thackeray, A.; Childs, J.D.; Brennan, G.P. A Randomized Clinical Trial of the Effectiveness of Mechanical Traction for Sub-Groups of Patients with Low Back Pain: Study Methods and Rationale. *BMC Musculoskelet. Disord.* 2010, **11**, 81.
24. Benditz, A.; Brunner, M.; Zeman, F.; Greimel, F.; Florian, V.; Boluki, D.; Grifka, J.; Weber, M.; Renkawitz, T. Effectiveness of a Multimodal Pain Management Concept for Patients with Cervical Radiculopathy with Focus on Cervical Epidural Injections. *Sci. Rep.* 2017, **7**.
25. Zhu, L.; Wei, X.; Wang, S. Does Cervical Spine Manipulation Reduce Pain in People with Degenerative Cervical Radiculopathy? A Systematic Review of the Evidence, and a Meta-Analysis. *Clin. Rehabil.* 2016, **30**, 145–155.
26. Rodine, R.J.; Vernon, H. Cervical Radiculopathy: A Systematic Review on Treatment by Spinal Manipulation and Measurement with the Neck Disability Index. *J. Can. Chiropr. Assoc.* 2012, **56**, 18–28.
27. Leininger, B.; Bronfort, G.; Evans, R.; Reiter, T. Spinal Manipulation or Mobilization for Radiculopathy: A Systematic Review. *Phys. Med. Rehabil. Clin. N. Am.* 2011, **22**, 105–125.
28. Efsthathiou, M.A.; Stefanakis, M.; Savva, C.; Giakas, G. Effectiveness of Neural Mobilization in Patients with Spinal Radiculopathy: A Critical Review. *J. Bodyw. Mov. Ther.* 2015, **19**, 205–212.
29. Boyles, R.; Toy, P.; Mellon, J.; Hayes, M.; Hammer, B. Effectiveness of Manual Physical Therapy in the Treatment of Cervical Radiculopathy: A Systematic Review. *J. Man. Manip. Ther.* 2011, **19**, 135–142.
30. Andersen, M.Ø.; Andresen, A.K.; Lorenzen, M.D.; Isenberg-Jørgensen, A.; Støttrup, C. Non-surgical treatment of lumbar radiculopathy. *Ugeskr. Laeger.* 2017, **179**, V05170397.
31. Ayub, A.; Osama, M.; Ahmad, S. Effects of Active versus Passive Upper Extremity Neural Mobilization Combined with Mechanical Traction and Joint Mobilization in Females with Cervical

Radiculopathy: A Randomized Controlled Trial. *J. Back Musculoskelet. Rehabil.* 2019, **32**, 725–730.

32. Afzal, R.; Ghous, M.; Shakil Ur Rehman, S.; Masood, T. Comparison between Manual Traction, Manual Opening Technique and Combination in Patients with Cervical Radiculopathy: Randomized Control Trial. *J. Pak. Med. Assoc.* 2019, **69**, 1237–1241.

33. Jellad, A.; Ben Salah, Z.; Boudokhane, S.; Migaou, H.; Bahri, I.; Rejeb, N. The Value of Intermittent Cervical Traction in Recent Cervical Radiculopathy. *Ann. Phys. Rehabil. Med.* 2009, **52**, 638–652.

34. Fritz, J.M.; Thackeray, A.; Brennan, G.P.; Childs, J.D. Exercise Only, Exercise with Mechanical Traction, or Exercise with over-Door Traction for Patients with Cervical Radiculopathy, with or without Consideration of Status on a Previously Described Subgrouping Rule: A Randomized Clinical Trial. *J. Orthop. Sports Phys. Ther.* 2014, **44**, 45–57.

35. Young, I.A.; Michener, L.A.; Cleland, J.A.; Aguilera, A.J.; Snyder, A.R. Manual Therapy, Exercise, and Traction for Patients with Cervical Radiculopathy: A Randomized Clinical Trial. *Phys. Ther.* 2009, **89**, 632–642.

36. Shafique, S.; Ahmad, S.; Shakil-Ur-Rehman, S. Effect of Mulligan Spinal Mobilization with Arm Movement along with Neurodynamics and Manual Traction in Cervical Radiculopathy Patients: A Randomized Controlled Trial. *J. Pak. Med. Assoc.* 2019, **69**, 1601–1604.

37. Kim, D.-G.; Chung, S.H.; Jung, H.B. The Effects of Neural Mobilization on Cervical Radiculopathy Patients' Pain, Disability, ROM, and Deep Flexor Endurance. *J. Back Musculoskelet. Rehabil.* 2017, **30**, 951–959.

38. Costello, M.; Puentedura, E.; Louie, J.; Cleland, J.; Ciccone, C.D. The Immediate Effects of Soft Tissue Mobilization versus Therapeutic Ultrasound for Patients with Neck and Arm Pain with Evidence of Neural Mechanosensitivity: A Randomized Clinical Trial. *J. Man. Manip. Ther.* 2016, **24**, 128–140.

39. Joghataei, M.T.; Arab, A.M.; Khaksar, H. The Effect of Cervical Traction Combined with Conventional Therapy on Grip Strength on Patients with Cervical Radiculopathy. *Clin. Rehabil.* 2004, **18**, 879–887.

40. Satpute, K.; Hall, T.; Bisen, R.; Lokhande, P. The Effect of Spinal Mobilization With Leg Movement in Patients With Lumbar Radiculopathy-A Double-Blind Randomized Controlled Trial. *Arch. Phys. Med. Rehabil.* 2019, **100**, 828–836.

41. Tambekar, N.; Sabnis, S.; Phadke, A.; Bedekar, N. Effect of Butler's Neural Tissue Mobilization and Mulligan's Bent Leg Raise on Pain and Straight Leg Raise in Patients of Low Back Ache. *J. Bodyw. Mov. Ther.* 2016, **20**, 280–285.

42. Moustafa, I.M.; Diab, A.A. Extension Traction Treatment for Patients with Discogenic Lumbosacral Radiculopathy: A Randomized Controlled Trial. *Clin. Rehabil.* 2013, 27, 51–62.

43. Wainner, R.S.; Fritz, J.M.; Irrgang, J.J.; Boninger, M.L.; Delitto, A.; Allison, S. Reliability and Diagnostic Accuracy of the Clinical Examination and Patient Self-Report Measures for Cervical Radiculopathy. *Spine* 2003, 28, 52–62.

44. Plaza-Manzano, G.; Cancela-Cilleruelo, I.; Fernández-de-Las-Peñas, C.; Cleland, J.A.; Arias-Buría, J.L.; Thoomes-de-Graaf, M.; Ortega-Santiago, R. Effects of Adding a Neurodynamic Mobilization to Motor Control Training in Patients With Lumbar Radiculopathy Due to Disc Herniation: A Randomized Clinical Trial. *Am. J. Phys. Med. Rehabil.* 2020, 99, 124–132.

45. Bukhari, S.R.I.; Shakil-ur-Rehman, S.; Ahmad, S.; Naeem, A. Comparison between Effectiveness of Mechanical and Manual Traction Combined with Mobilization and Exercise Therapy in Patients with Cervical Radiculopathy. *Pak. J. Med. Sci.* 2016, 32, 31–34.

46. Yang, F.; Li, W.-X.; Liu, Z.; Liu, L. Balance Chiropractic Therapy for Cervical Spondylotic Radiculopathy: Study Protocol for a Randomized Controlled Trial. *Trials* 2016, 17, 513.

47. Langevin, P.; Desmeules, F.; Lamothe, M.; Robitaille, S.; Roy, J.-S. Comparison of 2 Manual Therapy and Exercise Protocols for Cervical Radiculopathy: A Randomized Clinical Trial Evaluating Short-Term Effects. *J. Orthop. Sports Phys. Ther.* 2015, 45, 4–17.

48. Young, I.A.; Pozzi, F.; Dunning, J.; Linkonis, R.; Michener, L.A. Immediate and Short-Term Effects of Thoracic Spine Manipulation in Patients With Cervical Radiculopathy: A Randomized Controlled Trial. *J. Orthop. Sports Phys. Ther.* 2019, 49, 299–309.

49. Akkan, H.; Gelecek, N. The Effect of Stabilization Exercise Training on Pain and Functional Status in Patients with Cervical Radiculopathy. *J. Back Musculoskelet. Rehabil.* 2018, 31, 247–252.

50. Wibault, J.; Öberg, B.; Dederding, Å.; Löfgren, H.; Zsigmond, P.; Peolsson, A. Structured Postoperative Physiotherapy in Patients with Cervical Radiculopathy: 6-Month Outcomes of a Randomized Clinical Trial. *J. Neurosurg. Spine* 2018, 28, 1–9.

51. Halvorsen, M.; Falla, D.; Gizzi, L.; Harms-Ringdahl, K.; Peolsson, A.; Dederding, Å. Short- and Long-Term Effects of Exercise on Neck Muscle Function in Cervical Radiculopathy: A Randomized Clinical Trial. *J. Rehabil. Med.* 2016, 48, 696–704.

52. Dederding, Å.; Peolsson, A.; Cleland, J.A.; Halvorsen, M.; Svensson, M.A.; Kierkegaard, M. The Effects of Neck-Specific Training Versus Prescribed Physical Activity on Pain and Disability in Patients With Cervical Radiculopathy: A Randomized Controlled Trial. *Arch. Phys. Med. Rehabil.* 2018, 99, 2447–2456.

53. Kostadinović, S.; Milovanović, N.; Jovanović, J.; Tomašević-Todorović, S. Efficacy of the Lumbar Stabilization and Thoracic Mobilization Exercise Program on Pain Intensity and Functional

Disability Reduction in Chronic Low Back Pain Patients with Lumbar Radiculopathy: A Randomized Controlled Trial. *J. Back Musculoskelet. Rehabil.* 2020, 33, 897–907.

54. McMorland, G.; Suter, E.; Casha, S.; du Plessis, S.J.; Hurlbert, R.J. Manipulation or Microdiscectomy for Sciatica? A Prospective Randomized Clinical Study. *J. Manip. Physiol. Ther.* 2010, 33, 576–584.

55. Ghasabmahaleh, S.H.; Rezasoltani, Z.; Dadarkhah, A.; Hamidipanah, S.; Mofrad, R.K.; Najafi, S. Spinal Manipulation for Subacute and Chronic Lumbar Radiculopathy: A Randomized Controlled Trial. *Am. J. Med.* 2021, 134, 135–141.

56. Yin, M.; Mo, W.; Wu, H.; Xu, J.; Ye, J.; Chen, N.; Marla, A.S.; Ma, J. Efficacy of Caudal Epidural Steroid Injection with Targeted Indwelling Catheter and Manipulation in Managing Patients with Lumbar Disk Herniation and Radiculopathy: A Prospective, Randomized, Single-Blind Controlled Trial. *World Neurosurg.* 2018, 114, e29–e34.

57. Gudavalli, M.R.; Cambron, J.A.; McGregor, M.; Jedlicka, J.; Keenum, M.; Ghanayem, A.J.; Patwardhan, A.G. A Randomized Clinical Trial and Subgroup Analysis to Compare Flexion-Distraction with Active Exercise for Chronic Low Back Pain. *Eur. Spine J.* 2006, 15, 1070–1082.

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