



COMPARATIVE EVALUATION OF DEEP TRANSVERSE FRICTION MASSAGE AND CONVENTIONAL PHYSIOTHERAPY FOR PAIN RELIEF AND FUNCTIONAL DISABILITY IN PATIENTS WITH PIRIFORMIS SYNDROME

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ABSTRACT

Background: Sciatica and low back pain are frequently misdiagnosed as Piriformis Syndrome (PS), which is caused by the piriformis muscle trapping the sciatic nerve. The purpose of this study is to evaluate the effects of Deep Transverse Friction Massage (DTFM) on pain severity, disability, and hip range of motion (ROM) in comparison to traditional physiotherapy, which includes stretching, ultrasound, and moist heat. **Methodology:** A comparative study involving 36 individuals with PS diagnoses, ages 20 to 55, was carried out. Group B received stretching exercise, moist heat, and ultrasound therapy for eight days, whereas Group A received DTFM. The Numeric Pain Rating Scale (NPRS), the Oswestry Disability Index (ODI), and goniometry were used to measure the results. **Results:** Both groups improved significantly, however Group B (conventional physiotherapy) showed statistically better pain reduction outcomes. Both groups made notable progress, however Group B (Conventional Physiotherapy) showed statistically better outcomes in terms of pain reduction (NPRS post-test mean: 2.11 vs. 4.67) and functional impairment improvement across the majority of ODI subgroups and hip range of motion. **Conclusion:** When it comes to treating PS symptoms, conventional physiotherapy that incorporates stretching and ultrasonography is superior to DTFM alone.

KEYWORDS : Deep Transverse Friction Massage, Piriformis Syndrome, Stretching Exercise, Moist Heat, and Ultrasound Therapy

1. INTRODUCTION

The neuromuscular disorder known as piriformis syndrome (PS) is typified by a collection of symptoms that arise from one or both sciatic nerve divisions becoming trapped when they cross the sciatic notch.¹ Patients with piriformis syndrome have pain in the lower back, hip region, back of the thigh, leg, side of the foot, and the sciatic nerve root due to compression or irritation of the sciatic nerve. Pain, numbness, burning, unpleasant bowel motions, trouble walking, and trouble with other functional activities are other symptoms that patients encounter. If treatment is not received, it may result in problems with extended standing, walking, and sitting.²

PS is more common in women due to the biomechanics linked with the larger Q angle in their pelvis. PS can be caused by anatomical anomalies in the piriformis muscle, pelvic trauma, leg length disparity, or piriformis myositis. Its incidence rate with lower back pain may range from 5 to 36%.¹ There are two kinds of PS: Primary PS is caused by anatomical variations such as a divided Piriformis muscle or a split sciatic nerve. Secondary PS is produced by triggering events such as macro trauma and local ischaemic microtrauma from overuse or direct compression.³ A major trauma to the buttocks causes piriformis syndrome in half of all instances.⁴

Piriformis syndrome causes 0.3% to 6% of all occurrences of sciatic nerve and low back pain. Piriformis syndrome is estimated to affect around 2.4 million people per year, with an additional 40 million cases of low back pain and sciatica. Piriformis syndrome commonly affects middle-aged patients, with a male-to-female ratio of 1:6 observed. Piriformis syndrome can be caused by a hip or buttock injury, piriformis muscle hypertrophy (typically seen in athletes during periods of increased weight, lifting requirements, or pre-season conditioning), prolonged sitting (taxi drivers, office workers, cyclists), or skeletal abnormalities.⁵ The piriformis of the hip joint functions as an external rotator during extension, an abductor at 60 degrees, and an internal rotator at 90 degrees.⁶

piriformis muscular spasms, which can lead to the development of myofascial trigger points in reaction to changes in muscle demands. Hyperirritable nodules inside a taut band of skeletal muscle are known as myofascial trigger points. These nodules cause widespread and radiating pain along the sciatic nerve root in addition to local pain and sensitivity. Trigger points are palpable on the piriformis muscle's belly or at the level of the larger sciatic notch. A comprehensive history and physical examination, together with some specialised tests like Freiberg's sign, FAIR test, Lasegue sign, and Beatty test, are necessary for a clinical diagnosis of PS.¹

Myofascial release of trigger points in the buttock region reduces piriformis muscle spasm and relieves discomfort. Pain and suffering throughout daily tasks are greatly reduced by deep friction massage.⁷ The goal of friction massage is to keep the soft tissue structure of muscles, tendons, and ligaments mobile while preventing the development of adherent scars. Myofascial trigger points are compressed during deep transverse friction massage to elicit a reaction. Friction over a trigger point can cause a specific pattern of referred pain and the jump sign. Friction can be used after a trigger point has been reduced to eliminate any taut fascia that may have encouraged the trigger point.⁸

Deep friction massage can dissolve muscular adhesions and relieve scar tissue. It also helps maintain the mobility of soft tissues.⁹ Muscle stretching, which involves stretching a specific muscle or tendon to its elastic limit in order to achieve the normal length, improves circulation, boosts athletic performance, reduces stress and stiffness in the muscles, and lowers the chance of injury.¹⁰ Stretching is a type of exercise that involves stretching a specific muscle to increase its flexibility and restore its normal tone.¹¹ A moist heat pack will be applied for ten minutes.¹² Patients with piriform muscle syndrome are typically treated with piriform muscle stretching, a physiotherapy technique.

One of the most frequent causes of PS may be linked to

The goal of stretching is to release pressure from the sciatic

nerve and lengthen the piriform muscle. Piriform muscle stretching is performed in standing or prone positions using intricate motions such internal and external thigh rotation, knee and coxal articulation flexion, and coxal articulation adduction.¹³ In contemporary clinical settings, ultrasound therapy (UST) is perhaps the most commonly used electro-physical treatment for lower back pain (LBP). Ultrasound therapy is one of the most widely used electro-physical therapies used by physical therapists to treat lower back pain. Osteopaths, chiropractors, and sports therapists are among the other medical professionals who regularly use it to treat musculoskeletal conditions. The concept behind ultrasound therapy is to use ultrasonic waves to deliver energy to deep tissue regions, resulting in non-heat-related physiological changes. Ultrasound therapy can be administered either continuously or sporadically.¹⁴ Although both deep transverse friction massage and traditional physiotherapy are beneficial for piriformis syndrome, it is still unknown which is more successful. Therefore, we will compare the effects of traditional physiotherapy with deep transverse friction massage in this study.

2. METHODOLOGY

This comparison study was carried out at the Prem Physiotherapy and Rehabilitation College in Panipat. According to the inclusion criteria, 36 participants (N=36) between the ages of 20 and 55 were enlisted. Men and women who experienced gluteal pain that radiated to their lower limbs and backs were included in the study. Patients with straight legs show a positive rise below 60 degrees; subacute and chronic sciatic nerve compression is identified. Both the FAIR and FABER tests need to come out positive. Participants with intermittent vascular claudication, spondylolisthesis, a history of vertebral fractures, disc pathology, mechanical back pain, a history of spinal injuries, spinal TB, or rheumatoid arthritis were not allowed to participate in the study. On day 0, the patients were requested to complete the NPRS and ODI. Additionally, both groups' hip range of motion was assessed prior to and following an eight-day intervention. In group -A (DTFM), transverse friction massage was applied using the thumb, middle fingertips, and index finger. Keeping the body in line with the action, palpate the impacted structure and apply friction with your fingertips over the affected area on the longitudinal axis. To correctly separate fingers, the fingertips were moved forward and backward over the affected area for five minutes. After that, the technique was relaxed and repeated. Deep transverse friction massage for ten to fifteen minutes per session over the course of eight days. 15 minutes prior to DTFM, a moist heat pack was administered.¹²

In group B (conventional physiotherapy), piriformis stretching and ultrasonic therapy were used. - The patient assumes the prone position. The continuous mode was delivered with an intensity of 1.5 to 2.5 Watt/cm² and a frequency of 1 MHz. For 10 minutes, work in broad strokes along the piriformis muscle from the tendon to the lateral edge of the larger sciatic foramen. Stretching Exercise: Following ultrasonic therapy, a moist heat pack was applied for 15 minutes before stretching.¹² The patient was positioned in supine laying, which is lying on one's back with both feet flat on the bed and knees bent. Rest the ankle of one leg on top of the knee of the other. The physiotherapist pushed the thigh toward the chest and held the stretch for 30 seconds before repeating three to five times. 10 outcome measures.¹⁰

Assessments were conducted on Days 0 and 8:

1. NPRS: Pain intensity scale (0-10).
2. ODI: Measuring functional disability.
3. Goniometry: Measures hip range of motion (flexion, extension, abduction, adduction, and internal/external rotation).

3. RESULTS

3.1 Demographic Profile

Variable	Statistic/ category	Group A (n=18)	Group B (n=18)	Comparison
Age (years)	Mean $\pm$ SD	41.78 $\pm$ 9.41	44.22 $\pm$ 9.18	t = 0.789; p = 0.436 (NS)
Gender	Male, n (%)	4 (22.2%)	7 (38.9%)	—
Gender	Female, n (%)	14 (77.8%)	11 (61.1%)	—

The mean age was 41.78 in Group A and 44.22 in Group B (p > 0.05). Group A was 78% female, and Group B was 61% female, consistent with the higher prevalence of PS in women due to the wider Q-angle.

3.2 Pain Intensity (NPRS)

Within-group Comparison of NPRS Scores in Group A

Outcome	Pre-test mean $\pm$ SD	Post-test mean $\pm$ SD	Mean reduction	Paired t	p value
NPRS	7.72 $\pm$ 2.05	4.67 $\pm$ 1.19	3.05	5.869	<0.001

Interpretation: The mean NPRS score in Group A decreased from 7.72 $\pm$ 2.05 to 4.67 $\pm$ 1.19. The mean reduction of 3.05 points was statistically significant (p < 0.001).

Within-group Comparison of NPRS Scores in Group B

Outcome	Pre-test mean $\pm$ SD	Post-test mean $\pm$ SD	Mean reduction	Paired t	p value
NPRS	8.44 $\pm$ 0.78	2.11 $\pm$ 1.18	6.33	18.465	<0.001

Interpretation: The mean NPRS score in Group B decreased from 8.44 $\pm$ 0.78 to 2.11 $\pm$ 1.18. The mean reduction of 6.33 points was statistically significant (p < 0.001).

Between-group Comparison of NPRS Scores

Assess ment	Group A mean $\pm$ SD	Group B mean $\pm$ SD	Mean difference (A-B)	Inde- pendent t	p value	Result
Pre- test	7.72 $\pm$ 2.05	8.44 $\pm$ 0.78	-0.72	1.391	0.173	NS
Post- test	4.67 $\pm$ 1.19	2.11 $\pm$ 1.18	2.56	6.478	<0.001	S

Interpretation: The groups were comparable for NPRS at baseline (p = 0.173). At post-test, Group B had a significantly lower mean pain score than Group A (2.11 versus 4.67; p < 0.001), showing greater pain reduction in Group B.

Both groups showed significant reduction in pain (p < 0.05). However, Group B showed a more substantial decrease in mean scores:

3.3 Functional Disability (ODI)

Within-group Comparison of ODI Domain Scores in Group A

ODI domain	Pre-test mean $\pm$ SD	Post-test mean $\pm$ SD	Mean reduction	Paired t	p value
Pain intensity	4.56 $\pm$ 0.51	1.94 $\pm$ 1.11	2.62	8.040	<0.001
Personal care	4.06 $\pm$ 0.87	2.17 $\pm$ 1.20	1.89	5.239	<0.001
Lifting	3.78 $\pm$ 0.88	1.50 $\pm$ 1.04	2.28	6.873	<0.001
Walking	4.11 $\pm$ 0.68	1.76 $\pm$ 1.09	2.35	7.349	<0.001
Sitting	3.89 $\pm$ 0.68	1.71 $\pm$ 0.98	2.18	7.572	<0.001
Standing	3.61 $\pm$ 0.85	1.44 $\pm$ 0.92	2.17	7.572	<0.001
Sleeping	4.28 $\pm$ 0.67	1.67 $\pm$ 1.24	2.61	6.442	<0.001
Social life	3.78 $\pm$ 0.94	1.72 $\pm$ 1.22	2.06	5.248	<0.001
Travelling	4.44 $\pm$ 0.62	2.00 $\pm$ 0.91	2.44	9.457	<0.001

Employment	3.78 ± 0.88	2.28 ± 1.84	1.50	3.267	<0.001
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Interpretation: Group A showed statistically significant reductions in all ten ODI domains (all $p < 0.001$). The largest reductions were observed for pain intensity and sleeping, followed by travelling, walking, lifting, and standing.

Within-group Comparison of ODI Domain Scores in Group B

ODI domain	Pre-test mean ± SD	Post-test mean ± SD	Mean reduction	Paired t	p value
Pain intensity	4.83 ± 0.38	1.22 ± 0.94	3.61	16.717	<0.001
Personal care	4.39 ± 0.70	0.89 ± 0.68	3.50	14.235	<0.001
Lifting	4.61 ± 0.61	1.17 ± 0.62	3.44	18.644	<0.001
Walking	4.78 ± 0.55	0.72 ± 0.67	4.06	19.718	<0.001
Sitting	4.67 ± 0.59	1.39 ± 1.09	3.28	11.330	<0.001
Standing	4.72 ± 0.67	1.11 ± 1.18	3.61	11.330	<0.001
Sleeping	4.39 ± 0.85	1.39 ± 0.50	3.00	15.149	<0.001
Social life	4.72 ± 0.67	1.39 ± 0.50	3.33	11.660	<0.001
Travelling	4.61 ± 0.92	1.06 ± 0.54	3.55	14.482	<0.001
Employment	4.72 ± 0.75	1.44 ± 1.04	3.28	9.349	<0.001

Interpretation: Group B also showed statistically significant reductions in every ODI domain (all $p < 0.001$). The largest reduction occurred in walking, followed by personal care, lifting, standing, travelling, and social life.

Between-group Comparison of ODI Domain Scores at Pre-test and Post-test

ODI domain	Pre Group A	Pre Group B	Pre t (p)	Post Group A	Post Group B	Post t (p)
Pain intensity	4.56 ± 0.51	4.83 ± 0.38	1.794 (0.082)	1.94 ± 1.11	1.22 ± 0.94	2.097 (0.043)
Personal care	4.06 ± 0.87	4.39 ± 0.70	1.253 (0.219)	2.17 ± 1.20	0.89 ± 0.68	3.943 (<0.001)
Lifting	3.78 ± 0.88	4.61 ± 0.61	3.297 (0.002)	1.50 ± 1.04	1.17 ± 0.62	1.155 (0.256)
Walking	4.11 ± 0.68	4.78 ± 0.55	3.267 (0.002)	1.76 ± 1.09	0.72 ± 0.67	3.448 (0.002)
Sitting	3.89 ± 0.68	4.67 ± 0.59	3.688 (<0.001)	1.71 ± 0.98	1.39 ± 1.09	0.923 (0.362)
Standing	3.61 ± 0.85	4.72 ± 0.67	4.354 (<0.001)	1.44 ± 0.92	1.11 ± 1.18	0.933 (0.357)
Sleeping	4.28 ± 0.67	4.39 ± 0.85	0.431 (0.669)	1.67 ± 1.24	1.39 ± 0.50	0.890 (0.380)
Social life	3.78 ± 0.94	4.72 ± 0.67	3.449 (0.002)	1.72 ± 1.22	1.39 ± 0.50	1.061 (0.296)
Travelling	4.44 ± 0.62	4.61 ± 0.92	0.653 (0.518)	2.00 ± 0.91	1.06 ± 0.54	3.780 (<0.001)
Employment	3.78 ± 0.88	4.72 ± 0.75	3.450 (0.002)	2.28 ± 1.84	1.44 ± 1.04	1.685 (0.101)

Interpretation: At baseline, the groups differed significantly in lifting, walking, sitting, standing, social life, and employment, indicating that the ODI domains were not fully comparable before treatment. At post-test, significant between-group differences remained for pain intensity, personal care, walking, and travelling. Group B had lower post-test means in these domains.

3.4 Hip Range of Motion (ROM)

Within-group Comparison of hip ROM in Group A

Movement	Pre-test mean ± SD (°)	Post-test mean ± SD (°)	Mean increase (°)	Paired t	p value
Hip flexion	86.94 ± 8.93	115.83 ± 5.75	28.89	16.591	<0.001
Hip extension	7.77 ± 3.08	14.16 ± 4.62	6.39	8.102	<0.001
Hip abduction	6.38 ± 2.30	15.00 ± 5.14	8.62	8.841	<0.001
Hip adduction	13.89 ± 4.39	26.11 ± 5.30	12.22	11.251	<0.001
Hip internal rotation	10.28 ± 3.63	21.94 ± 5.46	11.66	8.592	<0.001
Hip external rotation	13.61 ± 3.76	26.39 ± 5.09	12.78	11.025	<0.001

Interpretation: Group A demonstrated statistically significant improvement in all six hip movements (all reported $p < 0.001$). The largest mean gain was observed in hip flexion, followed by external rotation, adduction, internal rotation, abduction, and extension.

Within-group Comparison of Hip ROM in Group B

Movement	Pre-test mean ± SD (°)	Post-test mean ± SD (°)	Mean increase (°)	Reported paired t	p value
Hip flexion	84.40 ± 10.41	110.83 ± 9.28	26.43	16.591	<0.001
Hip extension	10.00 ± 3.43	24.44 ± 6.16	14.44	8.102	<0.001
Hip abduction	8.88 ± 3.66	23.33 ± 4.85	14.45	8.841	<0.001
Hip adduction	13.61 ± 5.09	27.22 ± 4.28	13.61	11.251	<0.001
Hip internal rotation	9.72 ± 3.20	24.17 ± 3.54	14.45	8.005	<0.001
Hip external rotation	8.89 ± 3.23	23.61 ± 4.13	14.72	15.384	<0.001

Interpretation: The reported results indicate significant improvement in every hip movement in Group B (all $p < 0.001$). The greatest mean gains were observed in flexion, external rotation, abduction, extension, internal rotation, and adduction.

Between-group Comparison of Hip ROM at Pre-test and Post-test

Movement	Pre Group A	Pre Group B	Pre t (p)	Post Group A	Post Group B	Post t (p)
Hip flexion	86.94 ± 8.93	84.40 ± 10.41	0.786 (0.438)	115.83 ± 5.75	110.83 ± 9.28	1.944 (0.060)
Hip extension	7.77 ± 3.08	10.00 ± 3.43	2.053 (0.048)	14.16 ± 4.62	24.44 ± 6.16	5.667 (<0.001)
Hip abduction	6.38 ± 2.30	8.88 ± 3.66	2.452 (0.019)	15.00 ± 5.14	23.33 ± 4.85	4.998 (<0.001)
Hip adduction	13.89 ± 4.39	13.61 ± 5.09	0.177 (0.861)	26.11 ± 5.30	27.22 ± 4.28	0.691 (0.494)
Hip internal rotation	10.28 ± 3.63	9.72 ± 3.20	0.491 (0.626)	21.94 ± 5.46	24.17 ± 3.54	1.454 (0.155)
Hip external rotation	13.61 ± 3.76	8.89 ± 3.23	4.038 (<0.001)	26.39 ± 5.09	23.61 ± 4.13	1.799 (0.081)

Interpretation: At baseline, significant group differences were present in hip extension, abduction, and external rotation. At post-test, Group B had significantly greater hip extension and abduction ROM than Group A. No significant post-test differences were found for flexion, adduction, internal rotation, or external rotation.

Group B showed superior gains in mobility compared to Group A.

4. DISCUSSION

Piriformis syndrome is a neuromuscular condition in which the piriformis muscle compresses the sciatic nerve, causing discomfort, functional disability, and a lower quality of life. In this study, both the Deep Transverse Friction Massage (DTFM) and traditional physiotherapy groups showed significant within-group improvements in pain, disability, hip range of motion (ROM), and quality of life. However, no statistically significant differences were found across groups, suggesting that both therapies are equally beneficial. The higher number of female participants (70%) is comparable with the findings of Laha et al.,¹⁵ who found a higher prevalence of piriformis syndrome among women. The observed reduction in pain and impairment is consistent with research by Kanwal et al.² and Laha et al.¹⁵ who stated that piriformis syndrome was more common in women. The observed decrease in pain and impairment is consistent with research by Laha et al.¹⁵ and Kanwal et al.². Cyriax suggested that friction massage activates the gate control mechanism, stimulates mechanoreceptors, and lessens pain by disrupting myofascial trigger points, which could account for the analgesic effect of DTFM. In a similar vein, Peggy Honig¹⁹ found that sciatic nerve impingement is successfully reduced by deep tissue compression and cross-fiber friction. Alarab and Unver¹¹ and Park et al.¹³, who showed that piriformis stretching improves pain and hip mobility, corroborate the gains shown after traditional physiotherapy. Additionally, the results align with those of Guner et al.¹⁶ and Ahadi and Yousefi¹⁷, who observed notable improvements in pain, quality of life, and functional status after conservative treatment. The current results, however, diverge from those of Kutty et al.⁸ and Anjali⁴, who showed better results with manual therapy in conjunction with muscular energy approaches. This discrepancy may be attributed to variations in study design and intervention regimens.

The results show that while DTFM is useful in lowering trigger point sensitivity and breaking down adhesions, the combination of stretching and ultrasound offers more thorough relief.

In order to alleviate inflammation, ultrasound therapy encourages non-thermal physiological changes and deep tissue heating. This impact efficiently lengthens the piriformis muscle, which directly decompresses the sciatic nerve. This is followed by stretching and moist heat. These findings are consistent with earlier research by Imani et al.¹⁸, which found that stretching and ultrasound are very beneficial for PS. On the other hand, even tho Group A improved, DTFM might not be as successful as active stretching in addressing the underlying muscular tension. The two main risk factors that reacted better to the multimodal strategy were sedentary lifestyles (long periods of sitting) and higher Q-angles in females.

5. CONCLUSION

For individuals with Piriformis Syndrome, conventional physiotherapy—which includes Piriformis stretching and ultrasound therapy—is statistically superior than deep transverse friction massage in terms of pain reduction, functional disability improvement, and hip range of motion.

5.1 Limitations and Recommendations

The study's findings regarding the impact of deep transverse friction massage and traditional physiotherapy on pain and quality of life in patients with piriformis syndrome cannot be broadly applied due to the limited sample size. Long-term follow-up to determine the intervention's carryover effect was lacking. Only one location was used to gather the samples. The course of treatment lasted only eight days.

Recommendations for Future Study

It is advised to use a big sample size. In order to generalise the

findings, samples from a wider region might be included in future research.

REFERENCES

- Uttam, M., & Yadav, H. (2016). Effectiveness of dry needling on release of myofascial trigger points in acute piriformis syndrome: A case report. *Research and Reviews: Journal of Neuroscience*, 6(3), 1–4. <https://doi.org/10.37591/rjron.v6i3.990>
- Kanwal, R., Khan, J., Awan, W. A., Khan, R., & Malik, S. (2018). Stretching exercises versus deep friction massage for the management of piriformis syndrome. *The Rehabilitation Journal*, 2(2), 65–69. <https://doi.org/10.52567/trj.v2i02.29>
- Desai, V. S., & Anand, S. (2020). Prevalence of piriformis tightness with relevance of sitting duration in bankers. *Indian Journal of Forensic Medicine & Toxicology*, 14(3), 749–754. <https://doi.org/10.37506/ijfimt.v14i3.10458>
- Anjali, S. (2020). A study to assess the effectiveness of deep friction massage and muscle energy technique among piriformis syndrome patients with pain, disability, and limitations in the hip joint's internal rotation range of motion [Doctoral dissertation, PPG College of Physiotherapy].
- Hicks, B. L., Lam, J. C., & Varacallo, M. A. (2023). Piriformis syndrome. In *StatPearls*. StatPearls Publishing. <https://www.ncbi.nlm.nih.gov/books/NBK448172/>
- Saeed, Q., Malik, A. N., & Ghulam, S. (2017). Outcome of specific piriformis stretching technique in females with piriformis syndrome. *Journal of Pioneering Medical Sciences*, 7(4), 55–58.
- Ahmad Siraj, S., & Dadgal, R. (2022). Physiotherapy for piriformis syndrome using sciatic nerve mobilization and piriformis release. *Cureus*, 14(12), e32952. <https://doi.org/10.7759/cureus.32952>
- Kutty, N. N., Siddeeqe, S., Tamphaibema, H., Azharuddin, Othayoth, N., & Bineesh, C. P. (2020). Effect of muscle energy technique with deep friction massage on pain, disability and internal rotation range of motion of hip joint in individuals with piriformis syndrome. *Indian Journal of Physiotherapy and Occupational Therapy*, 14(1), 148–153. <https://doi.org/10.37506/ijpot.v14i1.3416>
- Athawale, V. K., Jethwani, D., Qureshi, M. I., & Dadgal, R. (2021). Combined effect of neural tissue mobilization and deep friction massage in piriformis syndrome: A research protocol. *Indian Journal of Forensic Medicine & Toxicology*, 15(2), 11–16. <https://doi.org/10.37506/ijfimt.v15i2.14261>
- Chaudhary, S., Sheikh, M., Chaudhary, N. I., Ambad, R., & Bankar, N. (2021). Effect of neural tissue mobilization in combination with ultrasonic therapy versus ultrasonic therapy in deep gluteal syndrome: A comparative study. *Natural Volatiles & Essential Oils*, 8(5), 1321–1337
- Alarab, A., & Unver, F. (2020). Stretching exercise versus tissue mobilization technique in piriformis syndrome. *European Journal of Medical and Health Sciences*, 2(6). <https://doi.org/10.24018/ejmed.2020.2.6.610>
- Huang, Z. F., Yang, D. S., Shi, Z. J., & Xiao, J. (2018). Pathogenesis of piriformis syndrome: A magnetic resonance imaging-based comparison study. *Zhonghua Yi Xue Za Zhi*, 98(1), 42–45. <https://doi.org/10.3760/cma.j.issn.0376-2491.2018.01.009>
- Park, J. C., Shim, J. H., & Chung, S. H. (2017). The effects of three types of piriform muscle stretching on muscle thickness and the medial rotation angle of the coxal articulation. *Journal of Physical Therapy Science*, 29(10), 1811–1814. <https://doi.org/10.1589/jpts.29.1811>
- Haile, G., Hailemariam, T. T., & Haile, T. G. (2021). Effectiveness of ultrasound therapy on the management of chronic non-specific low back pain: A systematic review. *Journal of Pain Research*, 14, 1251–1257. <https://doi.org/10.2147/JPR.S277574>
- Laha, K., Sarkar, B., Kumar, P., Patel, L., & Sarkar, N. (2018). Efficacy of hip abductor and extensor strengthening on pain, strength and lower extremity function in piriformis syndrome: A randomized clinical trial. *International Journal of Health Sciences and Research*, 8(9), 80–88.
- Guner, D., & Ozcete, Z. A. (2023). Evaluation of the efficacy of ultrasound-guided dry needling therapy and exercise in piriformis muscle syndrome. *Cureus*, 15(8), e43804. <https://doi.org/10.7759/cureus.43804>
- Ahadi, T., Yousefi, A., Sajadi, S., Yousefi, N., & Babaei-Ghazani, A. (2023). Comparing radial extracorporeal shockwave therapy and corticosteroid injection in the treatment of piriformis syndrome: A randomized clinical trial. *Journal of Bodywork and Movement Therapies*, 33, 182–188. <https://doi.org/10.1016/j.jbmt.2022.09.020>
- K. T., Fariz, A., & Hamidah, N. (2024). The effect of a combination of ultrasound and stretching on the pain scores of piriformis syndrome patients at the Padas Health Center, Ngawi Regency. *Indonesian Journal of Medicine*, 9(3), 349–353. <https://doi.org/10.26911/theijmed.2024.9.3.746>
- Honig, P. (2007). A case report of the treatment of piriformis syndrome: Applying modalities of therapeutic bodywork. *Massage Today*, 7(1), 10–11.