Majalah Ilmiah Fisioterapi Indonesia
Indonesian Scientific Journal of Physiotherapy

Case Reports / Case Studies
ISSN (Print): 2303-1921
ISSN (Online): 2722-0443
Volume 14, Number 2, Pages 601-605 (2026)
DOI: https://doi.org/10.24843/mifi.000001409

Comprehensive Physiotherapy Management Using Schroth Exercise in Adult Structural Scoliosis: A Case Report

Rahdiah Idarwati[1], Yery Mustari[2], Achwan Ramadhan[3], Meisya Putri[4], Astri Fadjri[5]

[1-5]Physiotherapy Study Program, Universitas Hasanuddin, Indonesia

Corresponding author:
Name: Rahdiah Idarwati
E-mail: rahdiahbr@gmail.com
Phone: +62 812-4309-8280

Received 10 February 2026; Revised 26 April 2026; Accepted 28 April 2026; Published 16 May 2026

Abstract

Background: Scoliosis is a three-dimensional spinal deformity characterized by a lateral curvature greater than 10° accompanied by vertebral rotation, which may result in functional limitations, pain, and reduced quality of life. Physiotherapy plays a key role in conservative management, particularly through Physiotherapeutic Scoliosis-Specific Exercises (PSSE), including the Schroth method.

Objective: This case report aimed to evaluate the effectiveness of multimodal physiotherapy incorporating Schroth-based PSSE in improving functional outcomes and reducing symptoms in an adult patient with structural scoliosis and delayed treatment history.

Methods: A 25-year-old female with S-type structural scoliosis underwent comprehensive physiotherapy assessment, including physical examination, postural analysis, and functional testing. The intervention consisted of electrotherapy, manual therapy, stretching, strengthening, gait training, pelvic control, and Schroth-based PSSE. Outcomes were measured using Manual Muscle Testing (MMT), Visual Analogue Scale (VAS), and functional performance during stair negotiation.

Results: Muscle strength improved from grade 4− to 4 across all assessed muscle groups. Pain scores remained 0 for both movement and rest, while tenderness decreased from 9 to 8 on the VAS. Functional performance improved, particularly in stair ascent and descent, indicating enhanced balance and postural control.

Conclusion: Multimodal physiotherapy incorporating Schroth-based PSSE demonstrated short-term improvements in muscle strength and functional performance in adult structural scoliosis. However, pain reduction was limited, indicating the need for longer intervention duration and follow-up.

Keywords
Scoliosis, physiotherapy, Schroth method, PSSE, gait training

Introduction

Scoliosis is defined as a three-dimensional spinal deformity characterized by a lateral curvature of at least 10° in the coronal plane accompanied by vertebral rotation along the longitudinal axis.[1] This condition represents a complex structural disorder that affects not only the coronal alignment but also the sagittal and axial planes of the spine, resulting in alterations in posture, biomechanics, and functional capacity.[2]

Based on etiology, scoliosis can be classified into idiopathic, congenital, neuromuscular, traumatic, and degenerative types, with adolescent idiopathic scoliosis being the most frequently reported form.[3] The diagnosis is established through clinical examination, particularly the Adams Forward Bend Test, and confirmed by radiological assessment using Cobb angle measurement on standard posteroanterior radiographs.[4] The severity of scoliosis is categorized based on Cobb angle into mild (10–25°), moderate (25–40°), severe (40–80°), and very severe (>80°), which serves as a key determinant in guiding treatment decisions.[5]

The prevalence of scoliosis increases with age, particularly in adult populations, where degenerative changes contribute to spinal deformity progression. Epidemiological data indicate that scoliosis affects approximately 8% of individuals over 25 years and may reach up to 68% in older populations.[6] Several risk factors have been identified, including female sex, genetic predisposition, hormonal influences, and neuromuscular imbalance.[7] Genetic studies have suggested the involvement of multiple genes and signaling pathways, such as GPR126 and calmodulin-related mechanisms, contributing to the pathogenesis of scoliosis.[8]

The progression of scoliotic curves is closely associated with periods of rapid growth, particularly during adolescence, with higher progression rates observed in females and in patients presenting with larger Cobb angles at initial diagnosis.[9] While early detection and intervention are crucial in preventing curve progression during skeletal growth, adult scoliosis presents distinct clinical challenges, including chronic pain, postural dysfunction, and reduced functional capacity.[10]

Conservative management remains the primary approach for mild to moderate scoliosis, with physiotherapy playing a central role. Physiotherapeutic Scoliosis-Specific Exercises (PSSE) have gained increasing attention as a targeted intervention aimed at correcting three-dimensional spinal deformities through active self-correction, postural stabilization, and integration of corrective movements into daily activities.[11] Among these approaches, the Schroth method is one of the most widely studied and clinically applied techniques. It utilizes a combination of sensorimotor training, postural correction, and rotational breathing to achieve three-dimensional spinal alignment and improve functional outcomes.[5]

Systematic reviews and meta-analyses have demonstrated that Schroth-based interventions are effective in reducing Cobb angle, decreasing trunk rotation, and improving quality of life in patients with scoliosis.[5,12] Furthermore, emerging evidence suggests that combining PSSE with other physiotherapy modalities, such as manual therapy, may enhance clinical outcomes compared with single-modality interventions.[13]

However, the majority of existing studies focus on adolescent populations undergoing early and continuous intervention. Evidence regarding the effectiveness of PSSE in adult patients, particularly those with delayed or interrupted treatment history,

remains limited. This gap is clinically relevant, as many patients discontinue therapy during adolescence and return in adulthood with more complex musculoskeletal adaptations, including muscle imbalance, altered gait patterns, and compensatory postural strategies.

In addition, the optimal integration of multimodal physiotherapy approaches including electrotherapy, manual therapy, strengthening, gait training, and pelvic control has not been clearly established in the literature. Most studies evaluate these interventions in isolation, resulting in limited understanding of their combined or synergistic effects in real-world clinical settings.[14]

Therefore, this case report aims to evaluate the effectiveness of a multimodal physiotherapy program incorporating Schroth-based PSSE in improving functional outcomes and reducing symptoms in an adult patient with structural scoliosis and a history of delayed treatment. This report also seeks to provide a detailed clinical description of therapeutic response in a complex case, thereby contributing to the existing evidence on adult scoliosis rehabilitation.

Methods

This study was conducted as a single-patient case report following the CARE (CAse REport) guidelines to ensure completeness, transparency, and reproducibility in clinical reporting. The aim was to describe the clinical characteristics, intervention process, and short-term outcomes of a multimodal physiotherapy program incorporating Schroth-based Physiotherapeutic Scoliosis-Specific Exercises (PSSE) in an adult patient with structural scoliosis.

The participant was a 25-year-old female diagnosed with S-type structural scoliosis. The patient had a prior history of physiotherapy treatment between the ages of 12 and 17 years, which was discontinued for approximately eight years before resuming treatment in 2025 at Emphysio Clinic, Makassar, Indonesia. Anthropometric measurements indicated a height of 157 cm and body weight of 52 kg. The patient reported no family history of scoliosis and no associated comorbidities.

Spinal deformity assessment using a scoliometer indicated an estimated Cobb angle of 35°, with thoracolumbar involvement characterized by trunk rotation angles of 12° in the thoracic region and 16° in the lumbar region. Although radiographic confirmation is considered the gold standard for Cobb angle measurement, this examination was not available in this case, representing a limitation in objective structural assessment.

A comprehensive physiotherapy assessment was conducted, consisting of subjective and objective evaluations. Subjective assessment included patient-reported symptoms such as low back pain, perceived spinal deformity, and gait disturbances. Objective assessment included static and dynamic postural observation, palpation, range of motion (ROM) examination, and functional movement analysis of the trunk and lower extremities.

Specific clinical tests were performed to support the diagnosis and functional evaluation. The Adams Forward Bend Test was used as a screening tool for structural scoliosis by identifying rib hump asymmetry. The Trendelenburg test was applied to assess hip abductor muscle function and pelvic stability during single-leg stance. The Active Straight Leg Raise (ASLR) test was used to evaluate lumbopelvic control and load transfer function. In addition, gait observation was performed to identify abnormalities across the gait cycle phases.

Pain intensity was assessed using the Visual Analogue Scale (VAS), a widely validated and reliable instrument for subjective pain measurement. Muscle strength was evaluated using Manual Muscle Testing (MMT), a standardized clinical method for assessing muscle performance and neuromuscular function. Functional performance was assessed qualitatively based on the patient's ability to perform daily activities, particularly stair ascent and descent, as well as transitional movements.

The intervention consisted of a multimodal physiotherapy program integrating electrotherapy, manual therapy, and exercise-based rehabilitation, including Schroth-based PSSE as the core component. Electrotherapy was administered at the beginning of each session to facilitate pain modulation and muscle relaxation. Infrared radiation was applied at a distance of approximately 40 cm from the skin surface for 10 minutes in a prone position. Transcutaneous Electrical Nerve Stimulation (TENS) with vacuum electrodes was applied bilaterally along the trunk for 10 minutes.

Manual therapy was performed using muscle release techniques targeting hypertonic muscles identified during assessment. Moderate pressure (approximately 30–40%) was applied for 10 minutes to improve tissue extensibility and reduce muscle tension. Stretching exercises were prescribed for muscles identified as shortened, including sternocleidomastoid, upper trapezius, serratus anterior, erector spinae, quadratus lumborum, levator scapulae, hamstrings, iliopsoas, and external oblique muscles. Static stretching techniques were applied with an initial dosage of eight counts per stretch and two repetitions per muscle group, with gradual progression based on patient tolerance.

Strengthening exercises were targeted at muscle groups identified as weak, including deep neck flexors, rhomboid major, quadriceps, and gluteus maximus. The exercise program included bridging variations, bird dog exercise, lunges, squats, and resistance band exercises. Each exercise was performed with a dosage of eight counts per repetition and five repetitions per set, adjusted according to patient response.

Gait training was implemented to address abnormal walking patterns. The intervention included walking over cones arranged in vertical and horizontal patterns, walking with a horizontal stick positioned at chest level to promote postural alignment, stair ascent and descent training, and walking with additional load using sandbags to enhance proprioceptive input and muscle activation.

Pelvic control training was performed in a prone position with external support applied to the right pelvis to correct pelvic asymmetry and improve lumbopelvic stability. This intervention aimed to facilitate activation of key stabilizing muscles, particularly the gluteus medius and quadratus lumborum.

Schroth-based PSSE was implemented as the primary therapeutic component. The exercises focused on three-dimensional self-correction, including axial elongation, controlled lateral shift, vertebral derotation, and rotational breathing techniques to improve spinal alignment and postural control. Exercises were performed in various positions and progressively modified based on patient tolerance and clinical response.

The intervention was delivered over two treatment sessions conducted on November 1 and November 4, 2025, with each session lasting approximately 120 minutes. Clinical progression was documented using the SOAP (Subjective, Objective, Assessment, Plan) framework to ensure systematic monitoring of patient response. The clinical course of the patient, including previous treatment history and current intervention timeline, is summarized in Table 1 to provide a clear overview of the sequence of events and therapeutic interventions.

Table 1. Clinical Timeline of the Patient

Time Period	Clinical Events
Age 12–17 years (2012–2017)	The patient underwent regular physiotherapy for scoliosis
Age 17–25 years (2017–2025)	Discontinuation of physiotherapy
Prior to November 1, 2025	Onset of low back pain and gait disturbance
November 1, 2025	Initial assessment and first physiotherapy session
November 4, 2025	Second session and follow-up evaluation

Primary outcome measures included muscle strength assessed using MMT, pain intensity measured using VAS, and functional performance evaluated based on stair negotiation and gait quality. Outcomes were assessed before and after the intervention to determine short-term clinical changes. Given the nature of a single-case report, data were analyzed descriptively by comparing pre- and post-intervention findings without inferential statistical analysis.

Ethical considerations were addressed by obtaining informed consent from the patient prior to participation. Although formal ethical approval was not required for this case report, all procedures adhered to principles of confidentiality, anonymity, and ethical clinical practice.

Results

Baseline clinical assessment indicated that the patient's vital signs were within normal limits, including blood pressure of 110/70 mmHg, respiratory rate of 18 breaths per minute, pulse rate of 78 beats per minute, and body temperature of 37.2°C. Postural observation revealed multiple asymmetries across anterior, posterior, and lateral views, including pelvic obliquity, shoulder asymmetry, scapular prominence, and lumbar deviation. Dynamic assessment further identified abnormal gait patterns characterized by forefoot initial contact, disruption of gait phases, and bilateral inward swing patterns.

Palpation findings indicated localized tenderness along the vertebral column (VAS = 9), while no pain was reported at rest or during movement (VAS = 0). Functional limitations were observed in several activities, particularly stair negotiation, which was associated with impaired balance. Range of motion was generally within normal limits; however, mild pain and restriction were noted during hip and knee flexion. Special tests revealed positive findings in the Adams Forward Bend Test, Trendelenburg Test, and Active Straight Leg Raise Test, indicating structural scoliosis, pelvic instability, and impaired lumbopelvic control. The quantitative and functional outcomes before and after the intervention are presented in Table 2.

Table 2. Changes in Muscle Strength, Pain Intensity, and Functional Performance Before and After Intervention

Variable	Pre-Intervention	Post-Intervention
Muscle Strength (MMT)		
Quadriceps	4−	4
Gastrocnemius	4−	4
Triceps brachii	4−	4
Middle–lower trapezius	4−	4
Latissimus dorsi	4−	4
Pain Intensity (VAS)		
Pain during movement	0	0
Pain at rest	0	0
Tenderness (vertebral region)	9	8
Functional Performance		
Stair negotiation	Less stable	More stable

Following two sessions of intervention, improvements were observed across several clinical parameters. Muscle strength increased consistently from grade 4− to grade 4 in all assessed muscle groups. Pain levels during rest and movement remained unchanged; however, tenderness showed a slight reduction. Functional performance improved, particularly in stair ascent and descent, indicating enhanced balance and postural control. The detailed physiotherapy intervention protocol, including identified clinical problems, applied modalities, and dosage parameters, is summarized in Table 3.

Table 3. Physiotherapy Intervention Protocol

No	Clinical Problem	Intervention	Dosage
1	Pain	Infrared Radiation (IRR)	10 min, prone, ±40 cm distance
		Vacuum TENS	10 min, bilateral trunk
2	Muscle tightness	Manual therapy (muscle release)	10 min, moderate pressure
		Stretching exercises	2 reps × 8 counts
3	Muscle weakness	Strengthening exercises	5 reps × 8 counts
		Functional strengthening (bridging, lunges, squat, bird dog)	10 min
4	Abnormal gait	Gait training	cone walking, stair training
5	Pelvic instability	Pelvic control exercise	prone with support
6	Spinal deformity	Schroth-based PSSE	10 min

Discussion

The findings of this case report demonstrate that a multimodal physiotherapy approach incorporating Schroth-based Physiotherapeutic Scoliosis-Specific Exercises (PSSE) may contribute to short-term improvements in muscle strength and functional performance in an adult patient with structural scoliosis. Although changes in pain intensity were minimal, improvements in balance and stair negotiation suggest meaningful functional adaptation.

Postural assessment in this case revealed multiple asymmetries, including pelvic obliquity, shoulder elevation, scapular prominence, and lumbar deviation. These findings are consistent with the characteristic presentation of structural scoliosis, which involves three-dimensional spinal deformity with compensatory curves to maintain overall balance.[1] The observed flattening of lumbar curvature further indicates altered sagittal alignment, which may contribute to increased mechanical loading on spinal structures and the development of low back pain.[10]

Dynamic gait analysis identified significant abnormalities, including forefoot initial contact, disruption of multiple gait phases, and inward deviation of the lower limbs. These findings suggest altered neuromuscular control and compensatory movement

strategies, likely resulting from pelvic asymmetry and muscle imbalance.[15] Previous studies have demonstrated that individuals with scoliosis exhibit altered gait kinetics and reduced movement efficiency, supporting the observations in this case.[16]

The presence of muscle imbalance was evident through both clinical examination and functional testing. Tightness in the erector spinae, quadratus lumborum, and external oblique muscles on one side, combined with weakness in stabilizing muscle groups such as the rhomboids and gluteal muscles, reflects a pattern consistent with scoliotic curvature and compensatory adaptation.[17] This imbalance contributes to impaired postural control and functional limitations, particularly in weight-bearing activities.

The implementation of a multimodal physiotherapy program addressed these impairments through complementary mechanisms. Electrotherapy was applied to facilitate pain modulation and muscle relaxation, although its direct impact on functional outcomes remains limited in the literature. Manual therapy contributed to improved tissue extensibility and neuromuscular relaxation, potentially enhancing the effectiveness of subsequent exercise interventions.[18]

Stretching and strengthening exercises were tailored to correct muscle imbalance by targeting shortened and weakened muscle groups, respectively.[19] This approach aligns with established rehabilitation principles aimed at restoring muscle length–tension relationships and improving joint stability.[20] Functional strengthening exercises such as lunges, squats, and bridging also contributed to improved lower limb strength and postural control, which are essential for gait and functional activities.[21]

The Schroth method served as the core intervention in this case, focusing on three-dimensional self-correction, including axial elongation, lateral shift correction, and rotational breathing techniques. Evidence from systematic reviews and meta-analyses indicates that Schroth-based PSSE can improve spinal alignment, reduce trunk rotation, and enhance quality of life in patients with scoliosis.[5,12] However, it is important to note that most of this evidence is derived from adolescent populations.

In adult patients, such as the case presented, the primary therapeutic goals differ from those in adolescents. While structural correction is limited after skeletal maturity, interventions focus on symptom management, functional improvement, and prevention of further progression.[22] The observed improvements in functional performance, particularly in stair negotiation, support the role of Schroth-based PSSE as part of a comprehensive rehabilitation strategy in adult scoliosis.

Gait training played a significant role in addressing abnormal walking patterns. Interventions such as cone walking, use of a horizontal stick, and stair training were designed to improve balance, coordination, and proprioceptive feedback.[23] These exercises likely contributed to the observed improvement in functional stability. Pelvic control training was also essential in correcting asymmetry and enhancing lumbopelvic stability.[24] The positive Trendelenburg test indicated weakness in the hip abductor muscles, which are critical for maintaining pelvic alignment during gait. Targeted exercises aimed at activating these muscles likely contributed to improved postural control.[25]

Despite these positive findings, several limitations must be acknowledged. The intervention was conducted over only two sessions, which is insufficient to evaluate long-term outcomes or sustained functional improvement. In addition, the absence of radiological assessment limits the ability to objectively evaluate structural changes in spinal curvature. The use of qualitative functional measures, without standardized outcome instruments such as the Oswestry Disability Index (ODI) or Scoliosis Research Society-22 (SRS-22), further restricts the generalizability of the findings. Another limitation relates to the multimodal nature of the intervention, which makes it difficult to isolate the specific contribution of each therapeutic component. While combined approaches reflect real-world clinical practice, the lack of controlled comparison limits the strength of causal inference.

From a clinical perspective, this case highlights the importance of individualized, multimodal rehabilitation strategies in managing adult scoliosis. The integration of Schroth-based PSSE with functional and postural training appears to provide synergistic benefits, particularly in improving functional capacity and postural stability. Future research should focus on longitudinal studies with larger sample sizes to evaluate the long-term effectiveness of multimodal physiotherapy in adult scoliosis. The inclusion of standardized outcome measures and objective imaging techniques is recommended to enhance the robustness and clinical relevance of future findings.

Conclusion

This case report demonstrates that a structured multimodal physiotherapy program incorporating Schroth-based Physiotherapeutic Scoliosis-Specific Exercises (PSSE), manual therapy, and functional training may contribute to short-term improvements in muscle strength and functional performance in an adult patient with structural scoliosis.

Following two intervention sessions, consistent improvements were observed in muscle strength across all assessed groups, along with enhanced functional stability, particularly during stair ascent and descent. These findings suggest improved postural control and neuromuscular coordination. However, pain reduction was minimal, as reflected by unchanged pain scores during rest and movement, with only a slight decrease in localized tenderness.

In adult scoliosis, where structural correction is limited after skeletal maturity, rehabilitation strategies are primarily aimed at symptom management, functional optimization, and prevention of further deterioration. The findings of this case support the potential role of Schroth-based PSSE as part of a comprehensive rehabilitation approach targeting three-dimensional postural correction and functional integration.

Nevertheless, the short duration of intervention and absence of follow-up limit the interpretation of long-term effectiveness. Future studies with longer intervention periods, standardized outcome measures, and objective imaging assessments are required to further evaluate the clinical impact of multimodal physiotherapy in adult scoliosis.

Author Contribution

Rahdiah Idarwati: Conceptualization, Methodology, Investigation, Data curation, Writing original draft preparation.
Yery Mustari: Methodology, Validation, Supervision, Writing review and editing.
Meisya Putri: Data curation, Investigation, Resources.
Achwan Ramadhan: Formal analysis, Visualization, Validation.
Astri Fadjri: Writing review and editing, Supervision, Project administration.

Acknowledgments

The authors express their sincere appreciation to the Physiotherapy Professional Program, Universitas Hasanuddin, for academic support and institutional resources. The authors also thank Emphysio Clinic for clinical collaboration and support throughout the study.

Conflict of Interest Statement

The authors declare no conflict of interest.

Funding Sources

This study received no external funding.

Ethics Statement

Written informed consent was obtained from the patient prior to participation. All procedures were conducted in accordance with ethical principles of confidentiality and clinical practice standards.

References

1. Roy S, Grünwald ATD, Lampe R. A non-invasive method for scoliosis assessment: a new mathematical concept using polar angle. PLoS One. 2022;17(9):e0275395.
2. Xu S, Li K, Jin L, Dong Y, Liang Y, Liu C, et al. Distribution of scoliosis in 2.22 million adolescents in mainland China: a population-wide analysis. J Glob Health. 2024;14:04117.
3. Li M, Nie Q, Liu J, Jiang Z. Prevalence of scoliosis in children and adolescents: a systematic review and meta-analysis. Front Pediatr. 2024;12:1399049.
4. Karavidas N, Tzatzaliaris D. Brace and physiotherapeutic scoliosis-specific exercises for adolescent idiopathic scoliosis: a prospective study following SRS criteria. Arch Physiother. 2022;12(1):22.
5. Ceballos-Laita L, Carrasco-Uribarren A, Cabanillas-Barea S, Pérez-Guillén S, Pardos-Aguilella P, Jiménez Del Barrio S. Effectiveness of the Schroth method in Cobb angle, quality of life and trunk rotation in adolescent idiopathic scoliosis: a systematic review and meta-analysis. Eur J Phys Rehabil Med. 2023;59(2):228-236.
6. Cao J, Sun W, Zheng Y, Shan S, Liu Y, Huang X, et al. Variations in scoliosis prevalence by age, sex, region, and subtype among Chinese children: a systematic review and modelling study. J Glob Health. 2024;14:04062.
7. Peng Y, Wang SR, Qiu GX, Zhang JG, Zhuang QY. Research progress on the etiology and pathogenesis of adolescent idiopathic scoliosis. Chin Med J (Engl). 2020;133(4):483-493.
8. Petrosyan E, Fares J, Ahuja CS, Lesniak MS, Koski TR, Dahdaleh NS, et al. Genetics and pathogenesis of scoliosis. N Am Spine Soc J. 2024;20:100556.
9. Farshad M, Götschi T, Bauer DE, Böni T, Laux CJ, Kabelitz M. Long-term outcomes of nonoperative treatment in adolescent idiopathic scoliosis: a 42-year follow-up. Spine Deform. 2022;10(6):1331-1338.
10. An JK, Berman D, Schulz J. Back pain in adolescent idiopathic scoliosis: a comprehensive review. J Child Orthop. 2023;17(2):126-140.
11. Seleviciene V, Cesnaviciute A, Strukcinskiene B, Marcinowicz L, Strazdiene N, Genowska A. Physiotherapeutic scoliosis-specific exercise methodologies used for conservative treatment of adolescent idiopathic scoliosis, and their effectiveness: an extended literature review of current research and practice. Int J Environ Res Public Health. 2022;19(15):9240.
12. You MJ, Lu ZY, Xu QY, Chen PB, Li B, Jiang SD, et al. Effectiveness of physiotherapeutic scoliosis-specific exercises on 3D spinal deformities: a systematic review and meta-analysis. Arch Phys Med Rehabil. 2024;105(12):2375-2389.
13. Zhang W, Li Y, Zhou Z, Jiang G, Huang H, Zhang G, et al. Efficacy of combined physiotherapeutic scoliosis-specific exercises and manual therapy in adolescent idiopathic scoliosis. BMC Musculoskelet Disord. 2024;25(1):874.
14. Ma K, Wang C, Huang Y, Wang Y, Li D, He G. Effects of physiotherapeutic scoliosis-specific exercises on idiopathic scoliosis: a systematic review and meta-analysis. Physiotherapy. 2023;121:46-57.
15. Jung JY, Kim JJ. Influence of customized foot orthotics on gait balance for pelvic asymmetry patients. J Mech Med Biol. 2019;19(5):1950039.
16. Khorramroo F, Rajabi R, Mousavi SH. Gait kinetics in individuals with scoliosis: a systematic review and meta-analysis. BMC Musculoskelet Disord. 2025;26(1):710.
17. Ko JY, Suh JH, Kim H, Ryu JS. Proposal of a new exercise protocol for idiopathic scoliosis. Medicine (Baltimore). 2018;97(47):e13336.
18. Sun Y, Zhang Y, Ma H, Tan M, Zhang Z. Spinal manual therapy for adolescent idiopathic scoliosis: a systematic review and meta-analysis of randomized controlled trials. Biomed Res Int. 2023;2023:7928429.
19. Warneke K, Lohmann LH, Wilke J. Effects of stretching or strengthening exercise on spinal and lumbopelvic posture: a systematic review with meta-analysis. Sports Med Open. 2024;10(1):65.
20. Princé. The shape of strength: how muscle architecture drives muscle function and malfunction. Sports Exerc Med Switzerland. 2026;[pages not available].
21. Angela C, Adnan QUA, Latif D, Jabbar R, Alam B, Tariq I. Effectiveness of strengthening exercises in improving functional activities of hemiplegic patients. Pak J Rehabil. 2024;13(2):56-63.
22. Ansari K, Singh M, McDermott JR, Gregorczyk JA, Balmaceno-Criss M, Daher M, et al. Adolescent idiopathic scoliosis in adulthood. EFORT Open Rev. 2024;9(7):676-684.
23. Meder K, LoJacono C, Rhea C. A systematic review of non-pharmacological interventions to improve gait asymmetries in neurological populations. Symmetry (Basel). 2022;14(2):281.
24. Paija DM, Shukla YU, Sutariya JM. Effect of core stability exercise on lumbopelvic pain among postnatal women: an evidence based study. Int J Health Sci Res. 2025;15(1):83-91.
25. Fujita K, Kabata T, Kajino Y, Iwai S, Kuroda K, Hasegawa K, et al. Quantitative analysis of the Trendelenburg test and invention of a modified method. J Orthop Sci. 2017;22(1):81-88.