Young Researcher
Peer Reviewed | International | Open Access Journal
ISSN: 2277-7911 | *Website: https://yra.ijaar.co.in/* | ***Volume-14, Issue-2 | April - May – June 2025***

Original Article

Impact of Modified TLSO on Pneumatic Pressure Distribution in Idiopathic Kyphoscoliosis- A Case Report

Susmita Sarkar[1], Mritunjay Kumar[2] & Hasan MD Arif Raihan[3]

[2]Prosthetist and Orthotist, CRC, Guwahati
[3]Lecturer Prosthetics & Orthotist, NILD, Kolkata

Manuscript ID: yrj-140211

ISSN: 2277-7911
Impact Factor – 5.958

Volume 14
Issue 2
April-May-June 2025
Pp. 76-85

Submitted: 18 May 2025
Revised: 12 June 2025
Accepted: 15 June 2025
Published: 21 June 2025

Corresponding Author:
Susmita Sarkar

Quick Response Code:

Web. *https://yra.ijaar.co.in/*

DOI: 10.5281/zenodo.15852180

DOI Link: https://doi.org/10.5281/zenodo.15852180

Abstract:

This study aimed to design and fabricate a cost-effective Modified Thoracolumbosacral Orthosis (TLSO) integrated with a pneumatic pressure system for the management of idiopathic kyphoscoliosis. The orthosis incorporates adjustable auxiliary sliding bars and a pneumatic air bladder to apply controlled corrective forces, allowing progressive spinal realignment in a patient-friendly manner. A case study was conducted on a patient with kyphoscoliosis, with initial and follow-up X-rays used to assess outcomes. The brace was customized based on spinal curvature, with pressure pads strategically placed at the apex of the deformity. The system effectively reduced the Cobb's angle to 5 degrees within three months, indicating significant spinal correction. The pneumatic mechanism provided targeted pressure without causing sudden stress to the spine and rib hump, while the adjustable features ensured comfort, improved posture, and reduced pain. Additionally, the orthosis was designed to be easily donned and doffed, helping to prevent muscle atrophy associated with prolonged brace usage. The results support the use of this Modified TLSO as an effective orthotic solution for managing flexible spinal deformities such as kyphoscoliosis.

Introduction:

Disability affects hundreds of millions of families in developing countries. Currently, around 10 percent of the total world's population, or roughly 650 million people, live with a disability. In most of the OECD (Organization for Economic Co-operation and Development) countries, females have higher rates of disability than males. As the population ages, this figure is expected to increase. It is mainly designed to reduce the sudden stress over the deformed structure.

How to cite this article:

Susmita Sarkar, Mritunjay Kumar, Hasan MD Arif Raihan (2025). Impact of Modified TLSO on Pneumatic Pressure Distribution in Idiopathic Kyphoscoliosis- A Case Report. Young Researcher, 14(2), 76-85. https://doi.org/10.5281/zenodo.15852180

Deformity of the spine is any abnormality of the formation, alignment, or shape of the vertebral column. Spine deformity causes when unnatural curvature occurs, as in scoliosis (side- to-side curvature) or kyphosis and Scheuermann's disease (front-to-back curvature). Mostly, the cause of Kyphoscoliosis is congenital (present at birth). Deformities do not commonly cause pain unless the change in structure restricts movement or reduces room in the spinal canal and puts pressure on the nerves.

Idiopathic kyphoscoliosis is a complex spinal deformity characterized by abnormal curvature and rotation of the thoracic and lumbar spine, commonly diagnosed during adolescence develops between 10 to 16 years of age. The thoracic spine has a natural degree of kyphosis (forward curvature) generally between 30 and 50 degrees. Kyphosis and lordosis refer to the curvature of the spine in the sagittal plane. When the spine is viewed laterally, a normal degree of lordosis (posterior curvature) can be seen in both the cervical and lumbar spine ranging between 35 and 80 degrees. The degree of thoracic kyphosis increases with age from 20 to 29 degrees in individuals younger than 40 years old, 53 degrees in those aged 60 to 74, and 66 degrees in patients older than 75 years (Ailon et al., 2015). Moderate kyphoscoliosis is a Cobb angle ranging from 25 to 100 degrees, whereas severe kyphoscoliosis is a Cobb angle greater than 100 degrees. Abnormalities in curvature and its clinical impact are affected by the severity and location of the curvature, the number of vertebrae involved, and the degree of axial rotation (Johari et al., 2016).

Although kyphoscoliosis occurs most commonly in the region of the thoraco-lumbar spine, it can also be noted in the cervico-thoracic region as well. Moderate kyphoscoliosis is a Cobb angle ranging from 25 to 100 degrees, whereas severe kyphoscoliosis is a Cobb angle greater than 100 degrees.

Epidemiology:

There has been a wide variation in the prevalence of kyphoscoliosis in different populations of the world. The global burden of idiopathic kyphoscoliosis is significant, affecting about 2-3% of the population worldwide (Hoelen et al., 2023). Being multi-factorial in nature a large number of diseases and pathologies that have a component of kyphoscoliosis, the exact epidemiology of this disease is unknown. A common cause of juvenile kyphoscoliosis is Scheuermann's disease which has an incidence of 0.4% to 8% in US, occurs commonly among boys, and affecting children between the ages group of 13-16 years (Yaman & Dalbayrak, 2014). Lack of epidemiological studies on kyphoscoliosis explains its unawareness and ignorance in India.

Rationale:

Idiopathic kyphoscoliosis not only affects spinal alignment and posture but also has significant implications for respiratory function, physical activity, and overall quality of life. Conservative management often includes the use of spinal Orthosis, such as thoraco-lumbo-sacral Orthosis (TLSOs), which aim to

prevent curve progression, reduce pain, and support functional mobility.

Traditional TLSOs, while effective in some aspects of postural correction, often present challenges related to user comfort, prolonged wear, and potential physiological consequences. Continuous use can result in complications such as muscle atrophy due to reduced trunk mobility, discomfort from rigid structures, and difficulty in donning and doffing. These issues often impact patient compliance and limit the long-term success of orthotic treatment.

In response to these limitations, a modified TLSO with a dynamic pneumatic pressure system has been developed. This Orthosis is designed to provide adjustable support through controlled intra-abdominal pressure, allowing dynamic adaptation to spinal deformities while relieving stress on the rib hump and spinal structures. Its user-friendly design enhances comfort, facilitates independent application and removal, and enables intermittent use to help preserve trunk muscle strength.

Despite the clinical potential of such a device, limited evidence exists regarding its impact on pressure distribution and biomechanical effects in patients with idiopathic kyphoscoliosis. Understanding how this modified Orthosis affects pneumatic pressure and spinal alignment can offer valuable insights into its therapeutic efficacy.

This case study aims to evaluate the impact of a modified TLSO with a pneumatic system on pressure distribution in a subject with severe idiopathic kyphoscoliosis. The findings may contribute to the development of more effective, comfortable, and user-friendly orthotic interventions for spinal deformities.

Methodology:

A case study design was adopted to study the impact of the brace on the curvature

Case Presentation:

A 14-year-old with Idiopathic kyphoscoliosis presented with a chief complaint of Pain and straightening spinal column since the last 6 years to the Department of Prosthetics and Orthotics to participate in the study. The patient's age, gender, weight, Height, and other relevant anthropometric data were collected. A thorough explanation of the study was provided, and the patient gave informed consent. The X-ray report indicates mild scoliosis with a single dorsal curvature in the thoracic region (apex at T8–T9, right side), a Cobb's angle of 15°, a thoracic kyphosis angle of 70°, lumbar lordosis of 70°, and a Risser sign of Grade IV and VAS pain Grade-III (Moderate Pain). After a comprehensive assessment, the patient was prescribed a Modified TLSO with Pneumatic pressure distribution. Casting of the Modified TLSO was done using the standard procedure, and fabrication was completed following the standard procedure for a Modified TLSO design.

Young Researcher
Peer Reviewed | International | Open Access Journal
ISSN: 2277-7911 | Website: https://yra.ijaar.co.in/ | Volume-14, Issue-2 |
April - May – June 2025

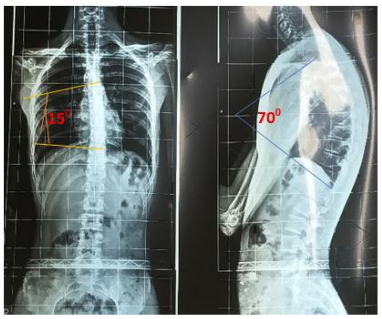


Figure 1: *X-ray – Anterior and Lateral Views*

Fabrication Procedure of Modified TLSO:

Measurement:

Measurement has taken as follows: -

1. ML at the chest level, Two fingers gap below axilla.
2. ML at and above the iliac spine.
3. ML at both thighs from left to right, G.T.

Casting:

Landmarks:

1. Right and left greater trochanter
2. Iliac spine
3. Floating ribs
4. Capture the spine and mark if it is visible
5. Mark if there is any hump is present

Casting procedure:

Casting can be taken in standing or lying by applying traction to maintain the spine as straight as possible.

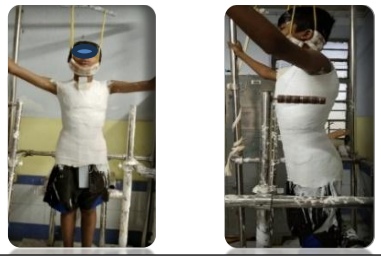


Figure 2: *Plaster Casting – Anterior and Lateral Views*

The body wrap casting technique has been used.

Modification:

Once the negative cast was converted to a positive mold, the modification was initiated by removing all the ridges and irregularities. Reduction of material has been done according to the measurement taken.

Molding:

Wrap molding has been done, and the thickness of the polypropylene sheet is decided according to the patient's weight.

Trim lines:

The anterior inferior trim line is kept as distal as the patient can tolerate. The midpoint should extend over the pubis when the patient is standing. The cut-away for the thighs allows just 90° of flexion for sitting in a firm chair. Flowing trim lines extend from both sides of the pubis proximal to the groin crease.

The standard anterior superior trim line is located at the base of the sternum to prevent impingement upon the xyphoid process. The base of the apron is at the level of the iliac crest pads and its width is approximately 50% of the width of the module at that level. The width of the apron is approximately 75% of the module at the midpoint between the base of the apron and the base of the sternum.

The standard posterior inferior trim line extends as low as possible, but not more than 1 to 2cm from the seat of a hard chair when the patient is sitting with hips flexed at 90°.

The standard posterior superior trim lines originate at the level of the tenth thoracic vertebra. The trim line flows posterior-laterally, descending sharply to the top of the iliac crest pad

Young Researcher
Peer Reviewed | International | Open Access Journal
ISSN: 2277-7911 | Website: https://yra.ijaar.co.in/ | Volume-14, Issue-2 | April - May – June 2025

and follows laterally along the iliac crest line to join the base of the apron anteriorly.

Lateral superior:

If a thoracic pad is needed, the lateral superior trim line is left proximal to contain the pad, posterior section at the level of lumbar there is butterfly cut out.

Materials and Approx. Cost Analysis

MATERIAL	QUANTITY	PRICE(INR)
Pneumatic pressure pump	1no	250/-
Ethaflex (2mm)	200cm	120/-
POP bandage	10nos	590/-
POP powder	10 kg	100/-
PP sheet (4mm)	20cm	2150/-
Velcro	1inch	138/-
Stockinet (nylon)	80mm	95/-
D-ring	1.5inches	75/-
Straps	1.5inches	225/-
TOTAL = 3573/-		

Specification of Components

1. Air bladder and pressure Pump system.
2. Molded TLSO with Pressure Pad and straps.

Air bladder and pressure Pump system: An Air bladder and pressure Pump consists of an inflatable cuff, a tube to connect the two, and an inflation bulb, which is also connected by a tube to the inflation bulb. The inflation bulb contains a one-way valve, to prevent inadvertent pressure leakage, with an adjustable screw valve with which the operator can lower the pressure in the system in a controlled manner. Mounted with a one-way valve, to prevent inadvertent pressure leakage, with an adjustable screw valve with which the operator can lower the pressure in the system in a controlled manner.

An air bladder is used to apply pressure to the apex of body. To inflate the bladder the pump was activated and opened to allow air flow in to the bladder. The bladder was deflated by opening valve, allowing air to escape through a small hole placed in line between the pump and valve, as shown in the diagram.

Fig 3: Air bladder and pressure pump

Product details:

Item Weight	150 Grams
Item Dimensions Length Width X Height	10 X 10 X 5 Centimeters
Material Feature	Virgin Rubber
Stainless Steel	Handle
Nickel-Plated: Tube Connector and Valve.	
Latex: Connecting Tube, Bulb, Inflatable Bag	

Components:

1. Aneroid pressure gauge with an air pressure release-valve.
2. Rubber bulb with palm fitting handle.
3. Connector to rubber tube.
4. Connecting tube.
5. Cuff with inflatable bladder

Straps: The attachments of straps are attached, one anterior side of the TLSO Brace .in anterior side two straps are

Young Researcher
Peer Reviewed | International | Open Access Journal
ISSN: 2277-7911 | Website: https://yra.ijaar.co.in/ | Volume-14, Issue-2 | April - May – June 2025

attached in same direction and one straps is attached in opposite direction another attachment is originated to one inch below to the anterior superior edge and it cross to opposite side shoulder and it's attached in posterior superior edge one inch below with D-ring and hook & loops.

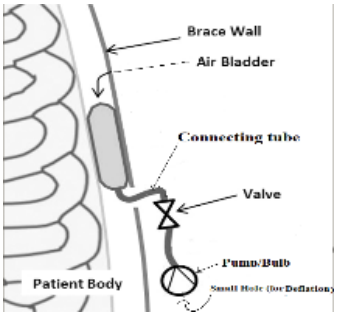
Fig 4: Air bladder and pressure pump

Working Principle:

Brace is padded to apply corrective pressure to the torso using a three-point concept: one pad is placed such that it will exert a force just below the spinal curve's apex. Two counter-pressure pads are placed opposite, above and below the curve. Thus, three pads are used for a single curve. Placement of pad is to exert an appropriate level of corrective pressure when the brace is tightened. This pressure is chosen with consideration of such factors as patient body mass, age, and gender. There is currently no standard for an ideal level of brace pressure.

To inflate the bladder, the pump was activated and the valve opened to allow air flow into the bladder. The bladder was deflated by opening the valve, allowing air to escape through a small hole placed in the line between the pump and valve.

Working Mechanism:



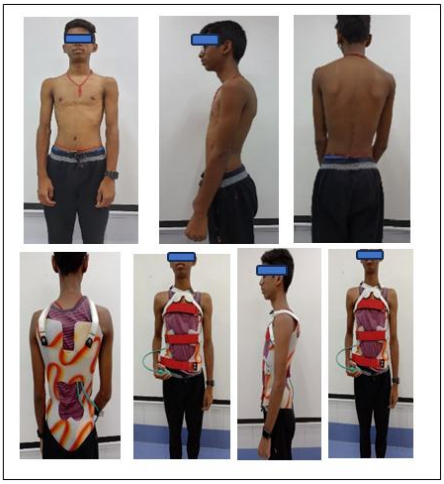


Fig 4: Patient standing with and Without Modified TLSO with Pneumatics Pressure control

Results:

The study aimed to evaluate the corrective impact of a modified thoraco-lumbo-sacral orthosis (TLSO) with a pneumatic pressure system on a 14-year-old patient diagnosed with idiopathic kyphoscoliosis. The patient wore the orthosis consistently for duration of four months. The therapeutic outcomes were monitored and assessed using clinical evaluation methods and radiographic imaging, specifically by comparing pre-intervention and post-intervention X-rays. At the outset, the patient's radiograph (baseline X-ray) revealed a thoracic kyphosis angle of 70° and a Cobb's angle of 15° with the apex of the curvature at the T8–T9 level. The sagittal plane X-ray also indicated exaggerated lumbar

Young Researcher
Peer Reviewed | International | Open Access Journal
ISSN: 2277-7911 | Website: https://yra.ijaar.co.in/ | Volume-14, Issue-2 | April - May – June 2025

lordosis and overall postural imbalance. These findings were consistent with moderate to severe kyphotic deformity and mild scoliosis.

Following 4 months of consistent orthotic use, the follow-up X-rays showed a remarkable reduction in the kyphotic angle by approximately 6–7 degrees, with final measurements indicating a kyphosis angle close to 63–64°. The Cobb's angle also showed improvement, reflecting the corrective influence of the orthosis in both coronal and sagittal planes.

The transverse loading mechanism of the TLSO effectively applied targeted lateral forces across the curvature, and the integrated pneumatic air bladder allowed dynamic pressure adjustment to the kyphotic apex. This contributed to progressive realignment of the vertebral segments and visible reduction in spinal curvature on imaging.

Clinically, improvements were corroborated using the Adams Forward Bend Test and scoliometer readings, which showed a reduction in the rib hump and trunk rotation. Additionally, the patient reported better postural comfort and ease in breathing, likely due to decreased thoracic compression.

In summary, the comparison between the initial and follow-up radiographs demonstrated that the use of the modified TLSO led to a significant and progressive improvement in both kyphotic and scoliotic curvatures. The 6–7° correction in Cobb's angle and improved postural balance over a 4-month period emphasizes the effectiveness of this low-cost, adjustable orthotic intervention in managing flexible spinal deformities.

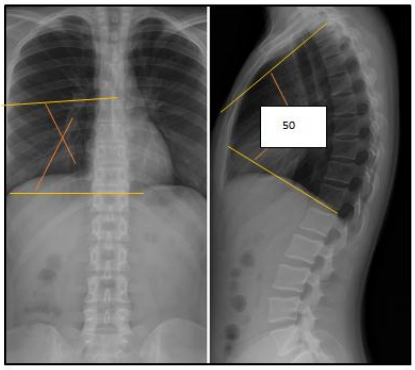


Fig 5: AP and lateral view of thoraco-lumbar spine after 4 months.

Discussion:

Every patient with kyphosis should be treated based on her/his current state and needs (Yaman & Dalbayrak, 2014b). The present case study demonstrates the clinical effectiveness of a custom-designed Modified TLSO integrated with a pneumatic pressure system in managing idiopathic kyphoscoliosis in an adolescent patient. While the clinical use of Orthosis remains debated due to potential long-term complications like muscle weakness and joint contractures, their short-term application is widely recognized for effectively reducing pain and disability during treatment, with minimal adverse effects (Choo & Chang, 2020). The Orthosis was worn consistently for four months, resulting in measurable improvement in spinal alignment as evidenced by radiographic and clinical assessments.

The initial X-ray indicated a thoracic kyphosis angle of 70° and a Cobb's angle of 15°, consistent with moderate kyphotic deformity and mild scoliosis. After 4 months of orthotic intervention, the follow-up X-rays revealed a significant reduction of

approximately 6–7° in the kyphotic angle, suggesting progressive correction through non-invasive means. Studies suggested wearing a dynamic hyperextension brace for a minimum of two hours daily over a period of at least six months may help enhance functionality and decrease the thoracic kyphosis angle (Sánchez-Pinto-Pinto et al., 2022). These results align with existing literature that supports the use of bracing in early-stage or flexible spinal deformities to slow or reverse curve progression.

The discussion of this finding emphasizes the biomechanical advantage provided by the Orthosis. The transverse loading mechanism and the pneumatic pressure pad enabled precise, controlled corrective forces that were dynamically adjustable based on patient comfort and curve severity (Lin et al., 2020). Unlike rigid braces that may cause discomfort and reduce compliance, the pneumatic component of this TLSO design allowed intermittent pressure adjustments, making it more user-friendly and potentially minimizing complications like muscle atrophy (Lou et al., 2025).

Additionally, the orthosis helped relieve thoracic compression, improving the patient's respiratory function — a common issue in kyphoscoliosis (Kennedy et al., 1989). Although no pulmonary function tests were performed in this study, the patient's self-reported improvement in breathing comfort supports this observation. Future studies should include objective pulmonary assessments to substantiate this clinical benefit.

It is also worth noting that the orthosis was fabricated using thermoplastic materials and commonly available components, costing approximately INR 3,573. This cost-effectiveness makes it accessible in low-resource settings where advanced orthotic interventions may not be affordable.

However, the findings should be interpreted in light of the study's limitations. Being a single case study, the outcomes cannot be generalized. There was no control group, and the follow-up period was relatively short. Furthermore, subjective improvements such as pain relief and comfort were not quantified using validated scoring systems, which limit the ability to compare outcomes objectively.

Despite these limitations, the study demonstrates promising results. It adds to the limited literature on dynamic orthotic solutions for kyphoscoliosis and highlights the feasibility of designing low-cost, adaptable devices for spinal deformity management in developing healthcare settings.

Limitation of the Study:

1. Single Case Design: This study was conducted on a single patient, which limits the generalizability of the results. The outcomes may not be representative of the broader population with idiopathic kyphoscoliosis.
2. Short Follow-up Period: The follow-up duration of 3–6 months, while adequate for initial observations, may not reflect the long-term effects or

sustainability of spinal correction achieved by the orthosis.

3. Subjective Measurements: Pain reduction and comfort were assessed based on subjective feedback from the patient without standardized pain scales or quality-of-life assessments post-intervention.
4. Lack of Control Group: Without a control group or comparison with other types of orthotic devices, it is difficult to assess the relative effectiveness of the modified TLSO.
5. No Objective Respiratory Evaluation: while improvement in breathing was noted, but no pulmonary function tests were performed to objectively measure respiratory improvement.

Conflict of Interest:

The authors declare that there is no conflict of interest regarding the publication of this study. The study was conducted independently without any commercial or financial relationships that could be construed as a potential conflict.

Conclusion:

This case study demonstrated the potential of a low-cost, custom-fabricated Modified TLSO with a pneumatic pressure system in correcting flexible spinal deformities associated with idiopathic kyphoscoliosis. The orthosis was able to reduce the kyphotic Cobb angle by 6–7 degrees and showed significant improvement in spinal alignment and patient-reported comfort. The dynamic nature of the pneumatic pressure system provided adjustable support, allowing targeted correction without compromising usability or comfort.

Despite its limitations, the study supports the clinical viability of this device as an effective and durable conservative treatment option, especially in resource-limited settings. Further research involving a larger cohort, longer follow-up, and objective respiratory and functional outcomes is recommended to validate and expand on these findings.

Declaration by Authors Ethical Approval: Approved

Acknowledgement: To the staffs of Department of Prosthetics and Orthotics, NILD

Source of Funding: None

References:

1. Ailon, T., Shaffrey, C. I., Lenke, L. G., Harrop, J. S., & Smith, J. S. (2015). Progressive Spinal Kyphosis in the Aging Population. *Neurosurgery*, *77 Suppl 4*, S164-172. https://doi.org/10.1227/NEU.0000000000000944
2. Choo, Y. J., & Chang, M. C. (2020). Effectiveness of orthoses for treatment in patients with spinal pain. *Yeungnam University Journal of Medicine*, *37*(2), 84–89. https://doi.org/10.12701/yujm.2020.00150
3. *Factsheet on Persons with Disabilities*. (2022). United Nations. Retrieved on 6th May 2025 from https://www.un.org/development/desa/disabilities/resources/factsheet-on-persons-with-disabilities.html
4. Hussain. (2014, June). *(PDF) Focus on Disability and Social Development Addressing Issues on Health, Mental Health, Education, Employment and*

Technological Advancements. ResearchGate. https://www.researchgate.net/publication/330578987_Focus_on_Disability_and_Social_Development_Addressing_Issues_on_Health_Mental_Health_Education_Employment_and_Technological_Advancements

5. Issac, S., & Das, J. M. (2025). Kyphoscoliosis. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK562183/
6. Johari, J., Sharifudin, M. A., Ab Rahman, A., Omar, A. S., Abdullah, A. T., Nor, S., Lam, W. C., & Yusof, M. I. (2016). Relationship between pulmonary function and degree of spinal deformity, location of apical vertebrae and age among adolescent idiopathic scoliosis patients. *Singapore Medical Journal*, *57*(1), 33–38. https://doi.org/10.11622/smedj.2016009
7. Kennedy, J. D., Robertson, C. F., Hudson, I., & Phelan, P. D. (1989). Effect of bracing on respiratory mechanics in mild idiopathic scoliosis. *Thorax*, *44*(7), 548–553. https://doi.org/10.1136/thx.44.7.548
8. Lin, Lou, Lam, & Cheng. (2020). The Intelligent Automated Pressure-Adjustable Orthosis for Patients with Adolescent Idiopathic Scoliosis (AIS): A Bi-Center Randomized Controlled Trial | Request PDF. *ResearchGate*. https://doi.org/10.1097/BRS.0000000000003559
9. Lou, Hill, Raso, & Donauer. (2025). Smart Brace versus Standard Rigid Brace for the Treatment of Scoliosis: A Pilot Study | Request PDF. *ResearchGate*. https://doi.org/10.3233/978-1-61499-067-3-338
10. Sánchez-Pinto-Pinto, B., Romero-Morales, C., López-López, D., de-Labra, C., & García-Pérez-de-Sevilla, G. (2022). Efficacy of Bracing on Thoracic Kyphotic Angle and Functionality in Women with Osteoporosis: A Systematic Review. *Medicina*, *58*(6), 693. https://doi.org/10.3390/medicina58060693
11. Yaman, O., & Dalbayrak, S. (2014). Kyphosis and review of the literature. *Turkish Neurosurgery*, *24*(4), 455–465. https://doi.org/10.5137/1019-5149.JTN.8940-13.0