EFFECTS OF SCHROTH PHYSIOTHERAPY METHOD ON ACTIVE RANGE OF MOTION OF THE SPINE

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Abstract. *One of the most common spinal deformities of the adolescent is idiopathic scoliosis. Even though the literature proposes a large number of nonsurgical treatments, existing studies for conservative treatment provide insufficient data to validate it. Physiotherapeutic scoliosis-specific exercises reflect the concept of conservative intervention recognised by the International Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) as effective in this medical condition. Among these exercises, the Schroth method suggests promising outcomes related to the effectiveness of stopping the disease progression and correcting the spinal deformity. An important criterion used is the active range of motion of the spine. Objective methods are required to assess this parameter, given that palpation and mobilisation are too subjective to produce accurate data or to be reproduced. Thus, many authors choose the fingertip-to-floor test to assess the active mobility of the spine. In the present paper, 15 case studies were monitored, and the conservative treatment programme consisted of individualised Schroth-based exercises for the specific functional diagnostic of this method. The programme was performed 3 times per week in the clinic and 3 times per week at the patient's home. The assessment involved performing the fingertip-to-floor test in the sagittal and frontal planes at the beginning of the therapy and 6 months later. The research results show that Schroth therapy can improve the active range of motion of the spine.*

Keywords: *adolescent idiopathic scoliosis, Schroth method, active range of motion of the spine.*

Introduction

"A scoliosis is a frontal plane postural distortion of the spine in which the spine has curves when viewed from posterior to anterior (or anterior to posterior)." (Muscolino, 2012, p. 613) Due to the coupling of lateral flexion with rotation, a scoliosis has a transverse component (Oatis, 2004). The most common type of scoliosis (around 80-90%) is called 'idiopathic', which means that its cause is unknown. The other approximately 10-20% percentages have a clear cause: congenital abnormalities, neuromuscular conditions, cerebral palsy, tumours, trauma or infectious diseases of the spine (Van der Plaats et al., 2007). This is a primary form of scoliosis that can be quite severe and usually affects adolescent girls (Werner, 2004). The incidence is four times higher in adolescent females than males, especially those experiencing a rapid growth spurt for unknown reasons (Roberto et al., 1997). Overall, about 2% to 3% of the adolescent population aged 10 to 16 years shows a lateral (frontal plane) curvature that exceeds 10 degrees (Lonstein, 2006). Benign pathology entails severe pain, cardiovascular compromise, social isolation or even early death, but only in extreme cases (Weiss et al., 2016). Based on the Cobb angle, scoliosis is classified as follows: mild scoliosis - when the angle is less than 30 degrees, moderate scoliosis - between 30 and 50 degrees and severe scoliosis - more than 50 degrees (Cordun, 2009). According to Stagnara's criteria, the paediatric orthopaedist "will decide the type of treatment: physical therapy if curvatures do not exceed a 30-degree Cobb angle, physical therapy combined with bracing if one curvature is greater than a 30-degree Cobb angle and surgery indication if the scoliosis deformity presents a Cobb angle above 50 degrees. These recommendations also depend on the skeletal maturity indicated by the Risser Sign." (Goga & Cordun, 2021, p. 519) As scoliosis develops during growth spurts but also in adulthood, the main goal of the therapeutic intervention is to stop curvature progression (Danielsson et al., 2007).

There are different classifications of scoliosis based on some criteria such as aetiology, possibility of correcting Cobb angle, method of treatment or age. In terms of curvature reduction, scoliosis can be defined as functional or structural, where functional involves the potential correction of the curvature through active mobilisation, and structural refers to a fixed deformity that cannot be completely corrected through active or passive movements (Weiss & Moramarco, 2013).

Scoliosis curves usually lead to loss of range of motion in the direction of bending on the convexity side. Although rarely, if a scoliosis curve became severe, it might have an impact on the ability of the heart to beat and the lungs to fill with air (Cramer & Darby, 1995). Manual therapy and movement therapy are beneficial for all dysfunctional soft tissues, whether they are locked short or locked long (Werner, 2004). The degrees of active range of motion are influenced by both the status of myofascial structures and the capsule-ligamentous system of the joints. Thus, the physiotherapeutic intervention must first assess the dominant cause of the restriction and secondly treat it accordingly. Range of motion of the curvature is essential for the effectiveness of conservative treatment, being one of its major objectives. Surgical treatment is taken into consideration when Cobb angle exceeds 50 degrees in a structural curvature.

The desired and ideal goal of conservative treatment is to correct the curvature or curvatures. The realistic goal of a therapeutic intervention is to stop curvature progression (Danielsson et al., 2007). Therefore, the main purpose of conservative treatment is to stop the disease progression and avoid surgery.

Conservative treatment involves a number of therapeutic interventions that include observation, physiotherapeutic scoliosis-specific exercises, bracing and education, which are recognised by the International Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT). "Conservative interventions remain controversial and are usually based on physical therapy exercises and treatments." (Lotan & Kalichman, 2019, p. 189)

After studying the methods and types of physical therapy schools, SOSORT has reached the conclusion that three key elements must be tracked in any type of movement intervention: 1. the individual's capacity for three-dimensional auto-correction; 2. behavioural change in daily activities; 3. stabilisation of corrected posture. Seven methods or schools are mentioned in the SOSORT guidelines: DoboMed, Global postural re-education, Lyon, MedX, Schroth, SEAS and side-shift approaches. (Negrini et al., 2018) Although scoliosis-specific exercises are used around the world, their overall relative effectiveness remains unproven (Romano et al., 2013). This is due to limited quantitative and qualitative data on these methods. However, there is currently "Level 1 evidence for the effectiveness of Schroth scoliosis exercises in the management of AIS [adolescent idiopathic scoliosis])" (Weiss et al., 2016, p. 570). All of these methods include manual therapy approaches, especially at the beginning of interventions to help the patient learn three-dimensional auto-correction. "Manual therapy techniques may also serve as adequate treatments for AIS due to their ability to improve range of motion and decrease muscle tone and pain.” (Lotan & Kalichman, 2019, p. 189)

The *aim* of the 15 case studies presented in this research is to determine whether the overall active mobility of the spine can be increased through physiotherapeutic scoliosis-specific exercises based on the Schroth method.

The research *objective* is to highlight the role of physiotherapeutic scoliosis-specific exercises in the conservative treatment of adolescent idiopathic scoliosis.

Research question: Can overall active mobility be increased within a short time using Schroth-based physiotherapeutic scoliosis-specific exercises during the complex conservative treatment?

Methodology

Participants

The 15 case studies included patients diagnosed with adolescent idiopathic scoliosis by the paediatric orthopaedist, who had received indication for conservative treatment. Physiotherapeutic scoliosis-specific exercises were performed at the “Terapie pentru Mișcare” (Therapy for Movement) Recovery Clinic between July 2020 and October 2020.

The following inclusion criteria were used:

- Patients diagnosed with adolescent idiopathic scoliosis;
- Risser sign 0 or 1 at the time of inclusion.

The exclusion criteria used were:

- Patients with scoliosis of known aetiology (e.g., congenital deformity of the vertebra, cerebral palsy);
- Risser sign 2, 3, 4 or 5 at the time of exclusion.

Table 1 shows data about the research participants.

Table 1. *Data about the research participants*

Item no.	Initials	Age	Gender	Diagnosis	Schroth functional diagnostic	Main curve	Risser sign
1	A.M.	13	F	Adolescent idiopathic scoliosis	TriLle	thoracic	1
2	A.S.	12	F	Adolescent idiopathic scoliosis	LriHleKt-	lumbar	0
3	B.E.	13	F	Adolescent idiopathic scoliosis	LleTri	lumbar	1
4	B.I.	12	F	Adolescent idiopathic scoliosis	LleTri	lumbar	1
5	B.P.	12	F	Adolescent idiopathic scoliosis	LleTri	lumbar	0
6	C.A.	12	F	Adolescent idiopathic scoliosis	LleKt-	lumbar	1
7	C.B.	13	F	Adolescent idiopathic scoliosis	Tri	thoracic	1
8	C.E.	13	F	Adolescent idiopathic scoliosis	LleKt-	lumbar	0
9	D.C.	12	F	Adolescent idiopathic scoliosis	TriLle	thoracic	0
10	I.P.	13	F	Adolescent idiopathic scoliosis	Tle	thoracic	1
11	M.A.	12	F	Adolescent idiopathic scoliosis	TriHle	thoracic	0
12	M.E.	13	F	Adolescent idiopathic scoliosis	TriLle	thoracic	0
13	M.O.	13	F	Adolescent idiopathic scoliosis	LleTri	lumbar	1
14	P.M.	12	F	Adolescent idiopathic scoliosis	LriKt-	lumbar	0
15	T.S.	12	F	Adolescent idiopathic scoliosis	Tri	thoracic	1

The Schroth diagnostic corresponds to the assessment classifications described by the International Schroth Three-Dimensional Scoliosis Therapy - Asklepios - Katharina Schroth method.

Instruments

Patients with adolescent idiopathic scoliosis should be regularly assessed every 6 months in the growth spurt period or even sooner if the physiotherapist notices progression. The assessment involves Cobb angle measurement, which is done on a full spine X-ray in the frontal and sagittal planes, and physical examination: Adams test, scoliometer measurements of trunk rotations, global and sitting height, fingertip-to-floor distance in the frontal and sagittal planes while bending.

In this research, the fingertip-to-floor test was used to assess active range of motion in three different directions: anterior flexion in the sagittal plane; left lateral flexion (bending) in the frontal plane; right lateral flexion (bending) in the frontal plane.

The fingertip-to-floor test is a very simple clinical test that "can routinely provide relevant information on trunk mobility" (Perret et al., 2001, p. 1569). This test also measures muscle flexibility (Cibinello et al., 2020). "Because the fingertip-to-floor test has excellent validity, reliability, and responsiveness, it can be used in clinical practice and therapeutic trials." (Perret et al., 2001, p. 1566) Although the normal value is zero in sagittal flexion (Cordun, 2009) and the closer the patient is to this value the better the test is considered to be performed, there are inter-individual variations in the results obtained. In a study of 50 normal patients, Merritt et al. (1986) found scores between 0 cm and 40 cm, with a mean of 4 cm. Therefore, this test will only be used in an intra-individual assessment protocol. It has been criticised for not measuring isolated active spinal flexion, as forward bending also involves pelvic, hip, thoracic and shoulder active range of motion (Cibinello et al., 2020). The distance of the toes assesses both the mobility of the spine and hip joints during trunk flexion and the suppleness of hamstring and gastrocnemius muscles (Cordun, 2009). There are no clear data about the normal values of the fingertip-to-floor test for forward bending.

This test is performed while standing barefoot, heels on the floor, feet at shoulder width and knees straight. Patients are asked to bend forward as far as possible in an attempt to touch the floor with their fingertips and to maintain this position for 15 seconds. After one instructional attempt, a second one will be made, and "the vertical distance between the tip of the middle finger and the floor is measured with a supple tape measure tape" (Perret et al., 2001, p. 1566).

Two examples of measuring the fingertip-to-floor distance are shown in Figure 1 (for the sagittal plane) and Figure 2 (for the frontal plane).

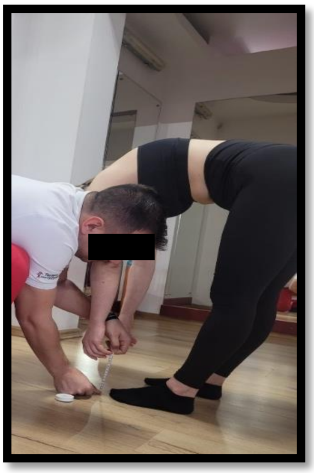

Figure 1. Example of measuring the fingertip-to-floor distance in the sagittal plane

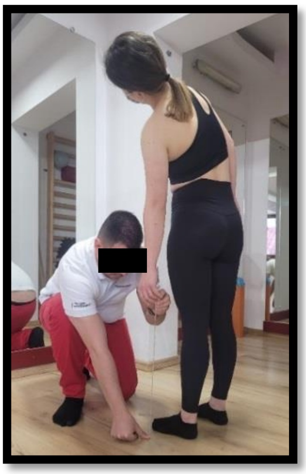

Figure 2. Example of measuring the fingertip-to-floor distance in the frontal plane

There is a weak relationship between structural changes revealed by MRIs and the range of motion observed in mobility tests. According to Quack et al. (2007), "more sophisticated mobility tests, such as the ZEBRIS system, do not provide more information than commonly used mobility tests" (p. 810).

Procedure

The Schroth method consists of scoliosis-specific sensorimotor, postural and breathing exercises and has shown promising results in different studies (Park et al., 2018). Schroth exercises are individualised for each patient and comply with the three key elements provided in the SOSORT guidelines, which include the following three important components: 1. muscle symmetry, 2. rotational angular breathing, 3. postural awareness. The Schroth therapist has the responsibility to properly assess and include the patient in a Schroth-specific diagnostic class according to which the exercise programme will be established.

Exercises are performed in front of a mirror so that the patient can receive constant feedback through the visual analyser. Voice feedback is also provided by the therapist to help the patient better understand when they are in a corrective posture.

The objects used in the Schroth method do not require large investments and consist of 1 or 2 mirrors, 3 to 5 rice bags, 2 plastic cylinders, 2 Schroth sticks, 1 wall bar, 1 gym mat and 2 or 3 physio balls of different sizes. All of this makes home care very accessible to most patients. Exercises are gradually introduced in order to be correctly performed and to avoid injury, according to each patient's learning pace.

"From the beginning, the goal is to make the patient understand the concept of correction of the centre of gravity in standing, sitting or daily living activity positions. Due to the fact that weight bearing is generally on the lower limb adjacent to the convexity of the main curve, the therapist will provide education about shifting it on both legs." (Goga & Cordun, 2021, p. 522)

Therapeutic interventions start with passive, assistive and self-mobilisation techniques, which are called corrections and have a specific pattern for each Schroth functional diagnostic. Such exercises train the patient's ability to reduce spinal deformity by correcting spinal alignment and posture in three dimensions. In this respect, range of motion is a key to therapeutic effectiveness and therefore should be regularly assessed by the therapist, especially because examination is not invasive. Moreover, these mobilisations will be integrated into the activities of daily living with the therapist and the patient's family.

Afterwards, the patient is taught angular breathing, which represents a Schroth-specific method of activating inhalation and exhalation while keeping the rib humps isometrically into the maximum expiratory movement and maintaining depressions into the maximum inspiratory rib positions to help correct trunk asymmetry.

When the physiotherapist considers that the patient has learned all three key elements (weight bearing correction, self-corrective mobilisations and angular breathing), integration into a therapeutic exercise can be initiated. The goal is to perform it by doing and keeping all specific corrections isometrically and performing 4 to 5 breathing cycles (as a beginner) up to 10 breathing cycles. Well-trained patients can do an exercise for 5 minutes with no break.

Each patient received an individualised programme based on the Schroth method, which consisted of exercises such as: symmetric and asymmetric muscle cylinder from standing; lateral muscle cylinder; Big Bow on the gym wall bars; standing cylinder using two Schroth sticks; prone contraction of the shoulder; mobilisation techniques, for example, posterior hip depression according to PNF pelvis patterns for the primary lumbar curve (Figure 3) or de-rotation of the posterior rib hump for the primary thoracic curve. These exercises were adapted to each patient's Schroth-specific functional diagnostic and physical fitness. In working with the patients the ethical principles were assured (data confidentiality and anonymity). Each exercise was performed in 4 sets of 10 breathing cycles, after a learning process aimed at the awareness of spinal corrections and hypercorrections, angular breathing and basic tension. The programme consisted of a first series of 5 daily sessions, followed by 6 sessions per week until the reassessment that took place 6 months later; thus, the patient performed 3 sessions per week in the clinic with a Schroth physiotherapist and 3 home sessions per week under the supervision of a parent. The programme was carried out over a period of 6 months.

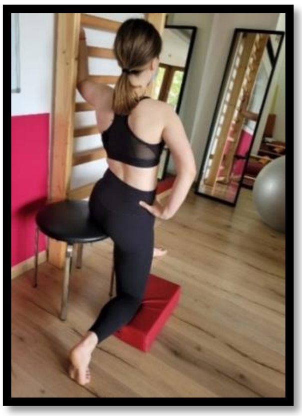

Figure 3. Pelvic correction mobilisations for the lumbar curve

Results

The 15 case studies included participants diagnosed with adolescent idiopathic scoliosis. Their medical histories allowed the centralisation of personal information: patients' first and last names, age, gender, medical diagnosis and functional diagnostic according to the Schroth method classification, main curve and Risser sign. All the case studies met the inclusion criteria and did not match the exclusion criteria.

Given that the physiotherapy programme was designed for a 6 month-period, complying with it was an important factor for the results obtained. The authors highlight the need for a guideline in this regard, which can be the subject of future research.

The fingertip-to-floor test included:

1. flexion in the sagittal plane (Figure 4);
2. left bending in the frontal plane (Figure 7);
3. right bending in the frontal plane (Figure 10).

1. Results for the finger-to-floor test in the sagittal plane

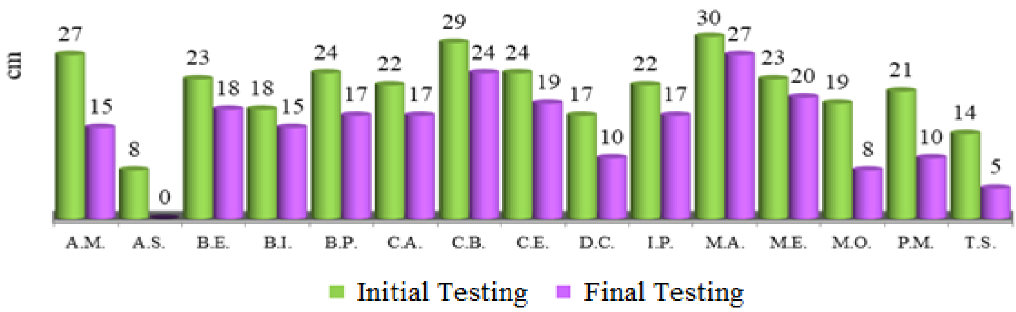

Figure 4. Initial and final results for the finger-to-floor test in the sagittal plane

Table 2. *Overall active range of motion of the spine flexion in the sagittal plane*

Test		Mean difference	Median	Standard deviation	Min	Max	Range	Coefficient of variation
Initial	21.40	-6.60	22	5.7	8	30	22	26.6%
Final	14.80		17	7.1	0	27	27	48.1%

The average finger-to-floor distances during the trunk flexion movement of patients with AIS decreased by 6.60 cm, from 21.40 in the initial test to 14.80 cm in the final test (Table 2 and Figure 5). The mean difference is within the confidence interval (-8.27; -4.93). Indices are relatively homogeneously dispersed in the initial test and inhomogeneous in the final test.

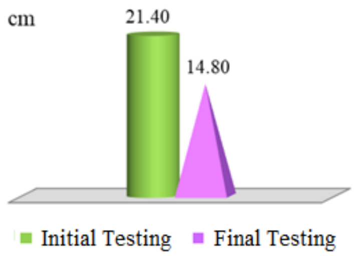

Figure 5. Initial and final average results for the finger-to-floor test in the sagittal plane

Table 3. *Statistical indicators for active range of motion of the spine in the sagittal plane*

Results of statistical indicators (FT-IT)				**Paired-samples *t* test**			
Mean	Standard deviation	Standard error	95% confidence interval	Effect size	t	df	p
-6.60	3.02	0.78	(-8.27; - 4.93)	2.19	8.47	14	< 0.001

According to the results of the paired-samples *t* test, the mean difference is statistically significant, with the significance threshold $p < 0.001$ for $t = 8.47$ and $df = 14$. The effect size indicates a very large mean difference (Table 3).

Table 4. *Active range of motion of the spine flexion in the sagittal plane after 6 months*

Mean difference (F-I)	Progress	The difference is	The progress is
-6.60	30.8%	Significant	Statistically significant

The decrease in the average finger-to-floor index after 6 months of applying the physiotherapy programme shows a mean difference of -6.60 (Table 4 and Figure 6), which is statistically significant.

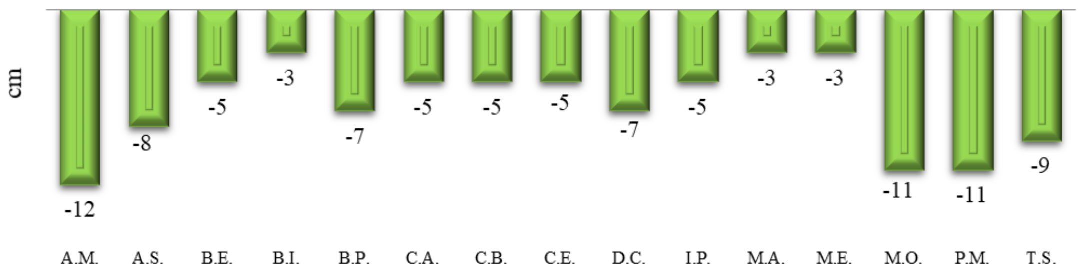

Figure 6. Difference between the initial and final results for the finger-to-floor test in the sagittal plane

2. Results for the finger-to-floor test in the frontal plane – Left bending

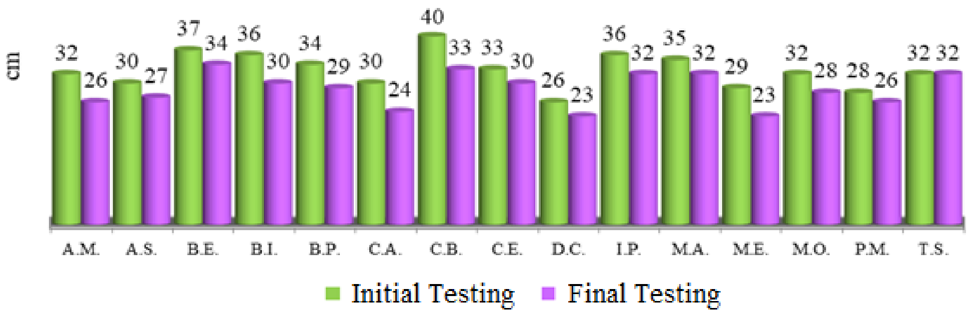

Figure 7. Initial and final results for the finger-to-floor test in the frontal plane – Left bending

Table 5. *Active range of motion of the spine in the frontal plane – Left bending*

Test		Mean difference	Median	Standard deviation	Min	Max	Range	Coefficient of variation
Initial	32.67	-4.07	32	3.8	26	40	14	11.5%
Final	28.60		29	3.7	23	34	11	12.8%

The degree of spinal mobility was assessed by measuring the finger-to-floor distance in the left frontal plane during the trunk flexion movement of patients with AIS. The average index decreased by 4.07 cm, from 32.67 in the initial test to 28.60 cm in the final test (Table 5 and Figure 8). The mean difference is within the confidence interval (-5.12; -3.01). The distances recorded in the left frontal plane are homogeneously dispersed in both tests.

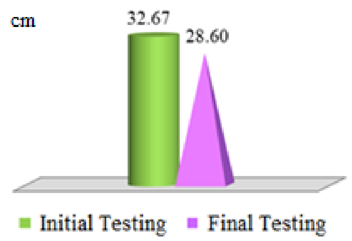

Figure 8. Initial and final average results for the finger-to-floor test in the frontal plane – Left bending

Table 6. *Statistical indicators for active range of motion of the spine in the frontal plane – Left bending*

Results of statistical indicators (FT-IT)				**Paired-samples *t* test**			
Mean	Standard deviation	Standard error	95% confidence interval	Effect size	T	df	P
-4.07	1.91	0.49	(-5.12; - 3.01)	2.13	8.26	14	< 0.001

According to the results of the paired-samples *t* test, the mean difference is statistically significant, with the significance threshold $p < 0.001$ for $t = 8.26$ and $df = 14$. The effect size (2.13) indicates a very large mean difference (Table 6).

Table 7. *Active range of motion of the spine in the frontal plane after 6 months – Left bending*

Mean difference (F-I)	**Progress**	**The difference is**	**The progress is**
-4.07	12.4%	Significant	Statistically significant

The decrease in the average finger-to-floor distance (left bending in the frontal plane) after 6 months of applying the physiotherapy programme is statistically significant (Table 7 and Figure 9).

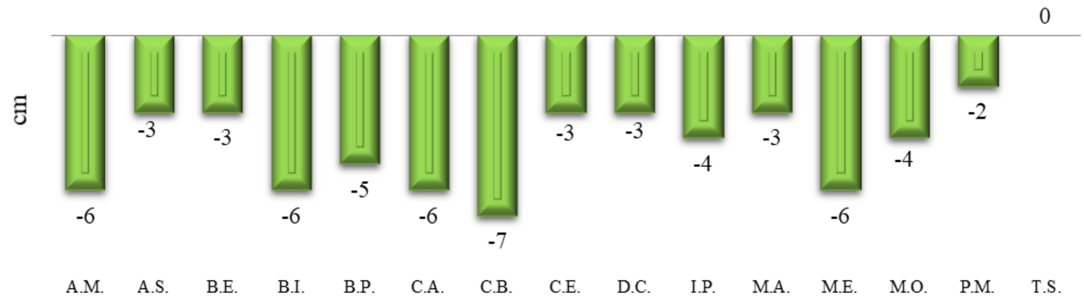

Figure 9. Difference between the initial and final results for the finger-to-floor test in the frontal plane – Left bending

3. Results for the finger-to-floor test in the frontal plane – Right bending

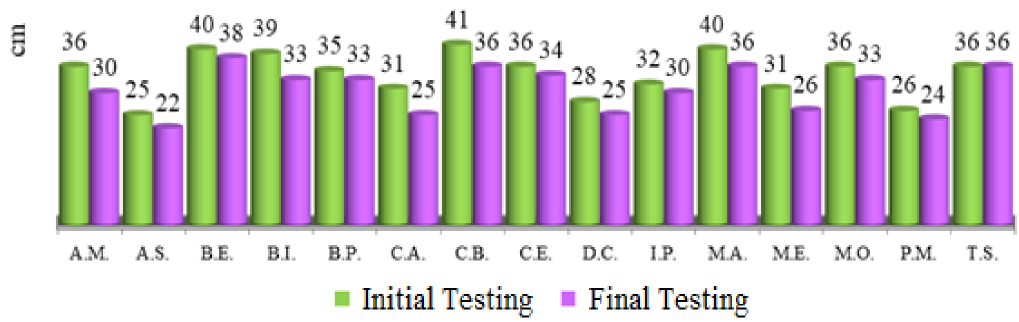

Figure 10. Initial and final results for the finger-to-floor test in the frontal plane – Right bending

Table 8. *Active range of motion of the spine in the frontal plane – Right bending*

Test		Mean difference	Median	Standard deviation	Min	Max	Range	Coefficient of variation
Initial	34.13	-3.40	36	5.1	25	41	16	15.0%
Final	30.73		33	5.2	22	38	16	16.8%

The active range of motion of spinal mobility during right bending in the frontal plane was assessed by measuring the finger-to-floor distance. The average index decreased by 3.40 cm, from 34.13 in the initial test to 30.73 cm in the final test (Table 8 and Figure 11). The finger-to-floor distances are evenly dispersed in the initial test and relatively homogeneous in the final test.

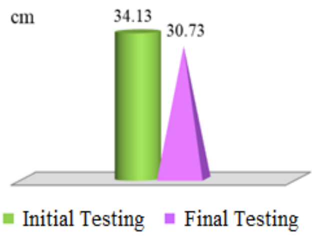

Figure 11. Initial and final average results for the finger-to-floor test in the frontal plane – Right bending

Table 9. *Statistical indicators for active range of motion of the spine in the frontal plane – Right bending*

Results of statistical indicators (FT-IT)				Paired-samples *t* test			
Mean	Standard deviation	Standard error	95% confidence interval	Effect size	t	df	p
-3.40	1.84	0.48	(-4.42; - 2.38)	1.84	7.14	14	< 0.001

The paired-samples *t* test shows a statistically significant mean difference, with $p < 0.001$ for $t = 7.14$ and $df = 14$ (Table 9). According to the effect size index (1.84), the mean difference is very large.

Table 10. *Active range of motion of the spine in the frontal plane after 6 months – Right bending*

Mean difference (F-I)	Progress	The difference is	The progress is
-3.40	10.0%	Significant	Statistically significant

The decrease in the average finger-to-floor distance (right bending in the frontal plane) after 6 months of applying the physiotherapy programme is statistically significant (Table 10 and Figure 12).

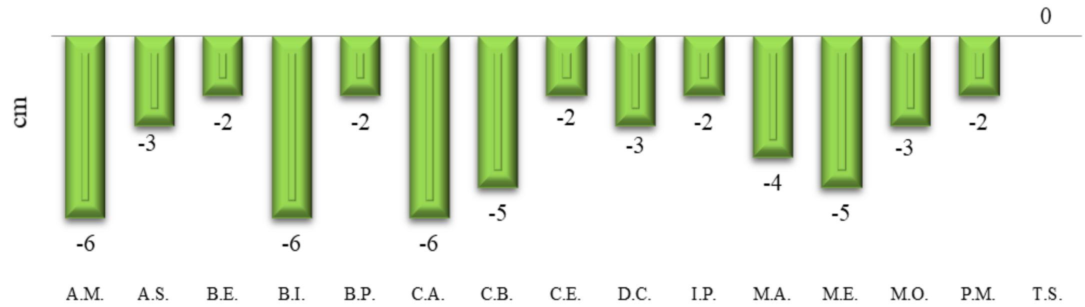

Figure 12. Difference between the initial and final results for the finger-to-floor test in the frontal plane – Right bending

Conclusion

Schroth therapy should become the form of physiotherapy of choice in the treatment of adolescent idiopathic scoliosis for patients who need conservative treatment. Therefore, more physiotherapists should specialise in Schroth therapy to be able to work with such patients. This could be developed as part of a future master’s programme in paediatric physiotherapy.

Regarding the finger-to-floor test, statistically significant differences were observed in the assessed planes and directions: in the frontal plane - right bending (flexion) and left bending (flexion); in sagittal plane - flexion. This shows an improvement in the spinal function of the tested patients instead of its progression.

The results could be the basis of a study on the effectiveness of other scoliosis-specific physiotherapy exercises or a comparison with a control group could be made in order to draw clearer guidelines for the conservative treatment of adolescent idiopathic scoliosis. Research that also highlights the range of motion of specific parts of the spine is needed, especially of its curves, given that this study examines the mobility of the entire spine.

Following the results obtained, the authors believe that spinal mobility is a key to therapeutic success. Although this relationship is well known, further research should aim to provide clearer guidance on mobility and curvature correction. On the other hand, practical experience has shown us that a spine with increased mobility (hypermobility) can be a situation in which scoliosis can develop much more aggressively without proper treatment. Therefore, clear directions are needed to better guide the therapist.

Given the long treatment period, the level of compliance and involvement in therapeutic solutions can influence the final outcomes. Thus, we emphasise the need to create clearer strategies for acceptance and compliance with the physiotherapy programme and wearing the brace, as it is a medium- and long-term programme. Currently, there is no clear direction or procedural guidance in this regard.

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