

Influence of Schroth Best Practice Therapy on Ventilatory Function in Adolescent Idiopathic Scoliosis: Randomized Controlled Study Design

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Abstracts: Introduction: Approximately 2%-3% of the population develops idiopathic scoliosis, making it the most prevalent structural spinal deformity in children as well as adolescents. Objective: To find out the efficacy of Schroth Best Practice therapy on pulmonary functions in adolescent idiopathic scoliosis. Methods: Sixty female subjects with adolescent idiopathic scoliosis were recruited from Outpatient Department at AlKasr Al-Ainy Hospital from May 2022 to July 2023 were enrolled in that study. They were randomized into two equivalent groups: Either the intervention group: Group A (Study group) consists of 30 subjects received the Schroth Best Practice exercises program for 18 weeks, or the control group Group B: consists of 30 subjects received traditional exercise program for 18 weeks. Both groups were given 3 sessions a week. Both groups received assessment of pulmonary functions: Forced Vital Capacity (FVC), forced expiratory volume in the first second (FEV1) As well as Peak Expiratory Flow (PEF) on 1st and 18th week. Measuring pulmonary function with digital handheld spirometer before and after treatment. These selective subjects were randomized into two equal groups. Results: There was a statistically significant difference ($p < 0.05$) among the two groups when comparing the mean values of all measured variables pre and post treatment. All analyses were performed at the 0.05 level of significance. With the initial alpha level set at 0.05, in favor of group A. Conclusion: Both Schroth Best Practice exercise program and traditional exercise program have a significant effect in adolescent idiopathic scoliosis, and the integrated Schroth Best Practice exercise program was more effective than traditional exercise alone.

Keywords: Adolescent Idiopathic Scoliosis, Schroth Best Practice Therapy Program, Ventilatory Function.

1. INTRODUCTION

Scoliosis is the most prevalent deformity of the immature spine, but it is more than just an abnormal lateral curvature of the spine; it also involves a rotational deformity of varying magnitude and sometimes a deformation in the sagittal plane. If neglected, this three-dimensional growth-related deformity can lead to a lifetime of pain, disability, low self-confidence, cardiovascular as well as respiratory complications, and possibly premature mortality in the adult patient. 4

Idiopathic scoliosis, the most common type, can cause the spine to curve at an average rate of 7.03 degrees per year if it is not treated. Therefore, treatment is necessary, even in the absence of a clear cause. 5

AIS, or adolescent idiopathic scoliosis, is a complicated 3D trunk deformation that affects 2-4% of the population. Only 8–9% of patients with AIS will benefit from bracing, whereas 0.1% will require spinal instrumentation as well as fusion surgery. 16

The main goal of scoliosis treatment is to reduce the curvature of the spine caused by the condition. To this end, several different therapeutic approaches have been created and used. 12

Schroth Best Practice's three-dimensional approach relies on concepts in sensory and kinesthetic theories. The treatment plan includes using proprioceptive, exteroceptive stimulation as well as mirror control to improve the patient's scoliotic posture as well as breathing pattern. 8

about 2/3 of people with sufficiently developed scoliotic curves also have a restricted pattern of respiratory problems, making scoliosis a major health issue both locally and globally. 1

Patients with AIS frequently exhibit restricted pulmonary impairment 21, which is associated with an elevated long-term mortality risk.14

As a result, it is essential to assess scoliosis patients for respiratory disorders as soon as possible. 15

Although nonsurgical treatment options are often recommended, there is currently inadequate evidence to differentiate between them. 7

The most efficient conservative therapeutic treatment for AIS is now an issue of much debate. The aim of this study is to search the available data on the efficacy of conservative treatment options for AIS. 17

Weak of respiratory muscles and decreased lung capacity are major consequences of AIS, leading to respiratory problems and exercise intolerance. 15

2. MATERIALS AND METHODS

2.1. Study Design

Sixty female subjects with adolescent idiopathic scoliosis were recruited from Outpatient Department at AlKasr Al-Any Hospital from May 2022 to July 2023 were enrolled in that study. They were randomized into two equivalent groups: Either the intervention group: Group A (Study group) consists of 30 subjects received the Schroth Best Practice exercises program for 18 weeks, or the control group Group B: consists of 30 subjects received traditional exercise program for 18 weeks. Both groups were given 3 sessions a week. Both groups received assessment of pulmonary functions: Forced Vital Capacity (FVC), forced expiratory volume in the 1st second (FEV1) As well as Peak Expiratory Flow (PEF) on 1st as well as 18th week. Measuring pulmonary function with digital handheld spirometer before and after treatment. These selective subjects were randomized into two equal groups.

2.2. Participants

We enrolled Sixty female subjects with AIS in this study. The inclusion criteria were age range from 12-18 years with idiopathic scoliosis with spinal curves ranged from 25°- 45° (moderate).

2.3. Exclusive Criteria

- 1- Other structural defects of the spinal vertebra rather than scoliosis.
- 2- Other neuromuscular or musculoskeletal diseases other than scoliosis.
- 3- Obese subjects with Body Mass index above 25.

4- other deformities in leg as leg length discrepancy.

Outcome measures

Pulmonary functions

Digital spirometer: It used to evaluate FVC, FEV1, and PEF

Height and weighting scale: will be utilized to measure the height as well as the weight to calculate the body mass index (BMI) of each patient.

Intervention

Group A will receive Schroth Best Practice exercises which consists of: Self-Correction exercises and Rotational Angular Breathing exercises.

Group B will receive Traditional exercises which consists of: stretching of the concave side and strengthening of the convex side, Hanging on wall Bar and electrical stimulation

Patients in both groups were given the treatment program three times per week for 18 weeks.

All the patients were cooperative throughout the treatment program, As well as the adherence rate was about 97%.

2.4. Sample Size

Before conducting the study, the researchers used G*POWER (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) to carry out a sample size calculation [T tests- unpaired t test, $\alpha=0.05$, $\beta=0.15$ (power 85%), and large effect size = 0.8, allocation ratio $N2/N1= 1$] and determined that $N=60$ participants would be ideal for avoiding type II error.

2.5. Data Analysis

The data was analyzed with SPSS 25 for Windows (SPSS Inc., Chicago, IL). There were two independent variables in the current study. Group A did the Schroth Best Practice exercise program for 18 weeks, while Group B did standard exercises. This was the (tested group); among subject factor, that had two levels. The 2nd factor had two levels (pre, post) and was the (measurement periods) within subject factor.

There were also three measured outcomes (FVC, FEV1, and PEF) in this study. The normality assumption, homogeneity of variance, as well as the existence of extreme scores were checked on the data before the final analysis. The study was carried out in preparation for analytical difference parameter calculations.

All three measures of lung function (FVC, FEV1, and PEF) were shown to be normally distributed and not contradict the parametric assumption when subjected to a descriptive analysis based on histograms of the normal distribution curve. Furthermore, no statistically significant difference was found when testing for homogeneity of covariance (p values > 0.05). Box as well as whisker plots were used for searching for outliers in the tested variable, and they didn't find any.

The findings of the Shapiro-Wilk test on the data showed that the FVC, FEV1, as well as PEF values were normally distributed. Therefore, we utilized a 2×2 mixed design MANOVA for comparing the tested variables of interest across groups and time periods. the significance level was set to be 0.05.

3. RESULTS

3.1. Subject Characteristics

Mean values for age, BMI, as well as height did not differ significantly ($p>0.05$) among the two groups, as determined by an independent t test. Table 1.

TABLE 1. Physical characteristics of patients in both groups (A&B)..

Items	Group A	Group B	Comparison		S
	Mean \pm SD	Mean \pm SD	t-value	P-value	
Age (years)	14.93 \pm 1.57	15.23 \pm 1.47	-0.761	0.45	NS
Body mass (Kg)	50.43 \pm 10.10	52.9 \pm 9.03	-0.997	0.323	NS
Height (cm)	160.46 \pm 10.06	160.6 \pm 9.25	-0.053	0.958	NS

Basic characteristics of participants. Mean values of age, body mass and height between both groups. *SD: standard deviation, P: probability, S: significance, NS: non-significant.

TABLE (2): The 2x2 mixed design Multivariate Analysis of Variance (MANOVA) for all dependent variables at different measuring periods between both groups.

Source of Variation	F-value	P-value	Partial Eta Square
Groups	17.928	0.0001*	0.49
Measuring periods	323.786	0.0001*	0.945
Interaction	36.551	0.0001*	0.662

*Significant at alpha level <0.05 .

Statistical analysis using 2x2 mixed design MANOVA indicates that there were significant effects of the tested group (the first independent variable) on the all tested dependent variables; (FVC, FEV1 and PEF) However, the interaction between the two independent variables was significant, which indicates that the effect of the tested group (first independent variable) on the dependant variables was influenced by the measuring periods (second independent variable).

TABLE (3): Mean \pm SD and p values of FVC pre and post-test at both groups.

FVC	Pre test	Post test	MD	% of change	p- value
	Mean \pm SD	Mean \pm SD			
Group A	61.2 \pm 7.84	73.69 \pm 4.64	-12.69	20.4	0.0001*
Group B	60.78 \pm 3.08	69 \pm 3.71	-8.22	13.52	0.0001*
MD	0.42	4.69			
p- value	0.789	0.0001*			

Mean values of FVC pre and post-tests in both groups.

*Significant level is set at alpha level <0.05 . SD: standard deviation. MD: Mean difference. p-value: probability value

TABLE (4): Mean ±SD and p values of FEV1 pre and post test at both groups.

FEV1	Pre test	Post test	MD	% of change	p- value
	Mean± SD	Mean± SD			
Group A	64.91±4.02	78.49 ±4.1	-13.58	20.92	0.0001*
Group B	62.8 ±4.84	69.23±5.03	-6.43	10.23	0.0001*
MD	2.11	9.26			
p- value	0.072	0.0001*			

Mean values of FEV1 pre and post-tests in both groups. *Significant level is set at alpha level <0.05. SD: standard deviation. MD: Mean difference. p-value: probability value

TABLE (5): Mean ±SD and p values of PEF pre and post-test at both groups.

PEF	Pre test	Post test	MD	% of change	p- value
	Mean± SD	Mean± SD			
Group A	60.59±3.5	76.93 ±2.03	-16.34	26.96	0.0001*
Group B	58.97±5.76	66.3±6.12	-7.33	12.43	0.0001*
MD	1.62	10.63			
p- value	0.193	0.0001*			

Mean values of PEF pre and post-tests in both groups *Significant level is set at alpha level <0.05. SD: standard deviation. MD: Mean difference. value: probability value

3.2. Treatment Impact

Using a 2x2 factorial design, we conducted a statistical study. The results of the (MANOVA) show that all three of the dependent variables (FVC, FEV1, as well as PEF) were significantly impacted by the tested group (the 1st independent variable). (F=17.928, P=0.0001*, Partial Eta Square=0.49). Nevertheless, there were significant impacts of the measurement periods (the 2nd independent variable) on the tested dependent variables (F= 323.786, P=0.0001*, Partial Eta Square=0.945). However, there was a statistically significant interaction among the two independent variables, suggesting that the impact of the tested group (the 1st independent variable) on the dependent variables was modulated by the measurement periods (the 2nd independent variable) (F=36.551, P=0.0001*, Partial Eta Square=0.662) (Table 2).

Table (2): The 2x2 mixed design Multivariate Analysis of Variance (MANOVA) for all dependent variables at different measuring periods between both groups.

3.3. Multiple Pairwise Comparison Tests (POST HOC TESTS)

1.FVC:

1-Within groups:

As shown in table (3), the mean SD values of FVC in the "pre" as well as "post" tests for group (A) were 61.27.84 as well as 73.694.64 for comparison within the group. The FVC was shown to be significantly higher at post-treatment compared to pre-treatment using multiple pairwise comparison tests (Post hoc tests; P value = 0.0001*). Group (B) members, on the other hand, had mean SD FVC values of 60.78 3.08 as well as 69 3.71 in the "pre" as well as "post" tests, respectively. The FVC was shown to be significantly higher at post-treatment compared to pre-treatment using multiple pairwise comparison tests (Post hoc testing) (P-value= 0.0001*).

2- Between groups:

Multiple pairwise comparison tests (Post hoc tests) demonstrated that there was no significant difference in the mean values of the "pre" test among the two groups ($P=0.789$), demonstrating that the tested group (the 1st independent variable) had no impact on FVC. Furthermore, multiple pairwise comparison tests (Post hoc tests) demonstrated that there was a statistically significant difference among the groups' mean results on the "post" test ($p=0.0001^*$), with the improvement favouring group A.

Table (3): Mean \pm SD and p values of FVC pre and post test at both groups.

2.FEV1:

1-Within groups:

Table 4 shows that in group (A), the mean SD FEV1 values for the "pre" and "post" testing were 64.914.02 as well as 78.494.1, respectively. There was a statistically significant improvement in FEV1 at post-treatment compared to pre-treatment ($P\text{-value} = 0.0001^*$), based on by multiple pairwise comparison tests (Post hoc testing). The group (B) had a FEV1 of 62.8 4.84 in the "pre" test as well as 69.23 5.03 in the "post" test. The FEV1 value was shown to be significantly higher at post-treatment compared to pre-treatment using multiple pairwise comparison tests (Post hoc testing) ($P\text{-value} 0.0001^*$).

2- Between groups:

Multiple pairwise comparison tests (Post hoc tests) involving the impact of the tested group (1st independent variable) on FEV1 showed that there were no significant changes in the mean values of the "pre" test among the two groups ($P=0.072$). Furthermore, numerous pairwise comparison tests (Post hoc tests) demonstrated that there was a statistically significant difference among the groups' mean results on the "post" test ($p=0.0001^*$), with the improvement favouring group A.

Table (4): Mean \pm SD and p values of FEV1 pre and post test at both groups.

3.PEF:

1-Within groups:

Table 5 shows that when comparing the "pre" and "post" tests within group (A), the mean SD PEF values were 60.59 3.5 as well as 76.93 2.03, respectively. PEF was shown to be significantly higher post treatment compared to pre-treatment using multiple pairwise comparison tests (Post hoc testing) ($P\text{-value} 0.0001^*$). In contrast, group (B) PEF values were 58.975.76 as well as 66.36.12 in the "pre" and "post" testing, respectively. PEF was shown to be significantly higher post treatment compared to pre treatment using multiple pairwise comparison tests (Post hoc testing) ($P\text{-value} 0.0001^*$).

2- Between groups:

Multiple pairwise comparison tests (Post hoc tests) showed that there were no statistically significant differences in the mean values of the "pre" test among the two groups ($P=0.193$), suggesting that the tested group (the 1st independent variable) had no impact on PEF. Furthermore, multiple pairwise comparison tests (Post hoc tests) demonstrated that there was a statistically significant difference among the groups' mean results on the "post" test ($p=0.0001^*$), with the improvement favouring group A.

Table (5): Mean \pm SD and p values of PEF pre and post test at both groups.

DISCUSSION

The aim of the study was to identify the impact of Schroth Best Practice therapy on pulmonary functions in AIS, and to compare the results to detect which is more effective.

60 female subjects with AIS were recruited in this study, as the incidence of idiopathic scoliosis is more frequent in females than males. The pre and post assessment was conducted using standard Pulmonary function test with digital spirometer.

They were distributed into 2 equal groups;

Group A were given Schroth Best Practice exercises program for 18 weeks while, Group B were given traditional exercise program for 18 weeks. Both groups were given three times a week.

The age of the subjects representing the study sample ranged from 12-18 years. FVC, FEV1, as well as PEF were measured in all of them on week one as well as week 18.

Measuring pulmonary function with digital handheld spirometer before and after treatment. These selective subjects were randomized into two equal groups.

According to the results of this study, the findings showed that The change percentage in FVC before and after intervention in Group A was (20.4%), in Group B before and after intervention was (13.52%);

And in FEV1 before and after intervention in Group A was (20.92%), in Group B before and after intervention was (10.23%);

And in PEF before and after intervention in Group A was (26.96%), in Group B before and after intervention was (12.43%);

improvement percentage of Cobb's angle in group A was 83.33% of cases, 13.33% did not change, 3.33% worsened. While in Group B; 6.67% of cases showed improvement, 46.6% did not change, 46.67% worsened.

These findings indicate a significant difference in both groups before and after intervention. It also indicates that the integrated Schroth Best Practice exercise program was more effective than traditional exercise program in enhancement of pulmonary functions and correcting Cobb's angle of Adolescent idiopathic scoliosis.

The findings of this study showed that Schroth Best Practice exercise program was more effective. This may be due to the combination of these exercise methodologies together as Schroth Best Practice exercises provide self-correction improve postural feeling with improvement in body awareness and Rotational Angular Breathing enhances rib mobility and breathing pattern.

This study was the first of its kind to compare between these types of exercises and manual therapy in one intervention. So, the results were compared with studies of selective exercises.

The patient learns to correct the abnormal posture of their spine and rib cage utilizing Schroth Best Practice scoliosis exercises, which has a beneficial impact on pulmonary function. Reduced rib mobility (e.g., a narrower intercostal gap) frequently leads to breathing difficulties on the concave side. Lung breathing on the collapsed side can be enhanced by correcting the rib cage deformity and increasing rib mobility by derotation during breathing.

The Schroth Best Practice approach has been shown to relieve breathing problems caused by scoliosis, so it's worth looking into if pulmonary impairment is an area concerned.

The results of the study came in line with a study using scoliosis-specific exercise approach which significantly

improve extensibility of the posterior muscular chain, enhance the patient's neural control of their posture as well as decrease pain in the spine. The nature of the motions, which are consistent with the underlying concepts emphasized by the approach, is responsible for these beneficial benefits. These actions were performed with an emphasis on excellent motions and the preservation of postural control, all the while keeping one's body aware of the contractility of one's muscles. 2

The study of (Lehnert-Schroth Best Practice C., 1992)¹³ also confirms these findings. Patients in the study performed a series of exercises designed to lengthen or strengthen the asymmetrical muscles while keeping a specified breathing pattern; these exercises included isometrics, mirror work, and exteroceptive as well as proprioceptive stimulations. The Schroth Best Practice approach relies primarily on auto-correction, which is described as a patient's capacity to reduce spinal deformity by voluntary postural readjustment of the spine in three dimensions. The goal of the Schroth Best Practice approach is to help patients get better motor control of their posture by having them practice corrective actions repeatedly with less and less feedback.

These results are in line with those of (Park et al., 2017)¹⁹, which highlighted the significance of the Schroth Best Practice method after it was shown to enhance Cobb angles, slow curve progression, decrease the necessity for surgery, strengthen back muscles, as well as enhance breathing function. Incorporating the Schroth Best Practice exercise program to conventional treatment enhances back muscle endurance in AIS patients, as confirmed by (Schreiber et al., 2015)²², and (Otman et al., 2005)¹⁸ reported that trunk muscle strength considerably improved following a six-week Schroth Best Practice exercise program.

Body imbalance as well as "preferred" movement patterns have been linked to the development of scoliosis, as explained by (Blum, 2002)³. A weak or malaligned area can lead to a tendency for compensation or the progress of another area.

It seems that the Schroth Best Practice approach results in a re-equilibrium of the muscle groups. Since the Schroth Best Practice technique places an emphasis on core muscular activation in nearly every position, it follows that strengthening these muscles is essential to the Schroth Best Practice approach's goal of achieving stability. The study by (Joo-Hee PARK et al., 2018) utilized this definition of quality of life and found that it was positively associated with changes in scoliosis, strength, balance, and appearance as well as with changes in self-image, function, satisfaction, as well as pain. 10

Cobb angle as well as trunk rotation of the scoliotic curve were shown to be reduced in every participant in the study by (Kocaman et al., 2021); The Cobb angle as well as trunk rotation of individuals in the Schroth Best Practice Group decreased more than those in the Core stabilization Group. Based on these results, it appears that the Schroth Best Practice exercise program is more effective than the core stabilization exercise program at decreasing Cobb angle or trunk rotation. 11

Another agreement with a Meta analysis study by (Dimitrijević et al., 2022)⁶ found that Compared to core stabilization exercises, the Schroth Best Practice technique produced a higher improvement in Cobb angle.

It comes in agreement with (H-R Weiss & Klein, 2006)²⁴ Patients in the scoliosis-intensive rehabilitation (Schroth Best Practice technique) group showed greater improvements (53%-70%) after 35 months of treatment than those in the control group (29%-44% improvement).

It also corroborated the results of a study involving 50 individuals with a mean age of 14. As a result of Schroth Best Practice's method, the mean Cobb angle, that was 26.1° prior to treatment, decreased to 23.45° post 6 weeks, 19.25° following 6 months, as well as 17.85° after a year 18

In a case report study, three patients having AIS and initial Cobb's angles of 20°, 20.3°, and 30.6° all reported significant pain relief and Cobb's angles of 10.8°, 4°, and 18.5° after receiving Schroth Best Practice's method 25

A patient having double major scoliosis (38° at the thoracic Cobb and 24° at the lumbar Cobb) is the subject of

additional case report study. The patient improved significantly after 6 months of treatment. The thoracic Cobb angle was lowered to 27.6° while the lumbar Cobb angle decreased to 19° using Schroth Best Practice's approach 9

The findings of this study came in accordance with (Kocaman et al., 2021)¹¹ who demonstrated that Schroth Best Practice exercises was better than core stability exercises in the reduction of scoliosis and associated problems in mild AIS, and core stability exercises were better than Schroth Best Practice exercises in the enhancement of peripheral muscle strength.

Resting lung function tests supported the decreased PEFr, FEV1, FVC, and MVV that are typical with severe scoliosis as described by (Shneerson JM, 1978)²³.

Significant enhancements in Cobb's angle, ribcage hump, vital capacity, chest expansion, as well as right thoracic longissimus muscular activation were found following 8 weeks of Schroth Best Practice training (Park and Shim, 2014). Only chest expansion was significantly better following 8 weeks of regular exercise. The results of this study show that the Cobb's angle, rib hump, pulmonary function, as well as sEMG values all improved thanks to the Schroth Best Practice exercises program.

Out results were supported with (Otman et al., 2005)¹⁸ who employed Schroth Best Practice exercises for 12 months in 50 adolescent patients having right thoracic scoliosis (four hours a session, 5 sessions a week, for the 1st 6 weeks, after that the session time reduced to 90 minutes every day at home) and observed that Cobb's angle was reduced from 26.10° to 23.45° following 6 weeks, to 19.25° post 6 months, as well as to 17.85° following 1 year.

In conclusion, this study showed that both integrated Schroth Best Practice exercise program and traditional exercise have significant effect before and after treatment. Integrated exercise program is more effective in quick improvement of pulmonary functions than traditional exercise program.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Acknowledgments

The researchers are grateful for the cooperation of all the adolescent and their parents and for their participation in this research.

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DOI: <https://doi.org/10.15379/ijmst.v10i4.2096>

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