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Effect of Barcelona Scoliosis Physical Therapy School Versus International Scoliosis Schroth Therapy in Adolescent Idiopathic Scoliosis

Eman M. Sharf Eldin[1], Abdel Aziz Ali [2], Saad Abdel Atti Gaballah[3], and Sara Y. Elsebahy[4]

[1]Physical therapist at Sherbin general hospital, Mansoura, Egypt.[2] Department of physical therapy for pediatrics, faculty of physical therapy, Kaferelshiekh university, Egypt.[3] Orthopedic surgery department, Damanhour teaching hospital, Egypt.[4] Department of physical therapy for pediatrics, faculty of physical therapy, Kafr El-Sheikh University, Egypt.

Abstract: Objective: This study was aimed to compare the effect of Barcelona scoliosis physical therapy school (BSPTS) scoliosis in relation to international scoliosis Schroth therapy (ISST) exercises on scoliosis cobbs' angle, angle of trunk rotation, and SRS-22 patient questionnaire in adolescent idiopathic scoliosis.

Methods: 30 patients with right thoracic AIS, aging from 12 to 15 years enrolled randomly in two equal groups. Group one underwent treatment using (BSPTS) exercises and group two underwent (ISST) exercises. Both groups received treatment for one hour three times per week for six months. Measurement of cobb's angle, angle of trunk rotation and SRS questionnaire were performed just before and after six months of treatment.

Results: This study showed marked improvement in cobbs' angle and ATR in both groups. The BSPTS group showed more response to treatment by 30.51±10.32% improve for ATR and 25.98±8.52% for Cobb's angle. The ISST group showed less response to treatment by 16.18±6.26% improve for ATR and 18.23±3.16% for Cobb's angle.

Conclusion: Both schools are appropriate in dealing with AIS, in spite that BSPTS has upper hand on ISST in managing AIS and improvement of cobb angle and ATR as it has better percentage of improvement.

Keywords: adolescent scoliosis, cobb's angle, Schroth, Barcelona scoliosis physical therapy, scoliosis treatment.

Introduction:

"Skolios"(curved, crooked) is an old Greek word that means "scoliosis" in English. Scoliosis consider the most common deformity affecting spine in children and teenagers. Scoliosis could be defined as lateral curvature of the spine or more recent definition is complicated three-dimensions structural spinal condition. [(1)] Etiology, age of onset, type, and severity of curvature are the criteria that can be used to classify scoliosis. Rate of curve progression, pattern, and degree of three-dimensional deformity are distinguishing characteristics of each variety. Critical signs for a poor prognosis in idiopathic scoliosis include a rapid curvature advancement and an early onset of the condition. [(2)]

Idiopathic scoliosis is confirmed if a non-idiopathic scoliosis has been eliminated. Despite the AIS cause is unknown, a plenty of environmental and genetic factors are thought to play a role [(3)]. It is divided into three categories: juvenile scoliosis, which affects children aged 4 to 10, accounts for 10 to 15% of all idiopathic scoliosis in children [(4)], adolescent scoliosis, which affects children aged 11 to 18, accounts for about 90% of cases of idiopathic scoliosis, and adult scoliosis. [(5)]. Non-idiopathic type is classified into Congenital scoliosis, Neuromuscular scoliosis, Mesenchymal scoliosis [(6)]. Adolescent idiopathic scoliosis (AIS): is the abnormal coronal curvature of the spine (Cobb angle ≥10º) that affects 0.5–5.2% of children ages 10–18 years. It affects girls more than boys with prevalence ratio from 1.5:1 to 3:1Since mild diseases often have no symptoms, early and regular screens are often necessary for diagnosis, followed by radiographic confirmation. intervention is mostly depending on the amount of the curvature, with a wait-and-see approach for mild cases, bracing for moderate cases, and surgical intervention for severe cases according to latest SRS recommendations. [(7)] Scoliosis is diagnosed by taking a complete patient history, including personal growth and family history, and then physically examining the patient for upright posture, uneven leg length, shoulder height disparities, truncal shift, and pelvic tilt. Early and routine screening has proven to be effective in the management of AIS. [(8)] The Adams' forward bend test, in which the patient bends forward at the waist with the knees straight and the examiner looks for rib cage asymmetry and spinal deformity, is perhaps the most common screening test for scoliosis. [(9)] Scoliometers provide quantitative measurement of truncal rotation, with >5-7º deemed abnormal. However, they are less sensitive. [(10)]

Conservative management:

Management of AIS is mostly determined by the risk of advancement. Once skeletal maturity is reached, the likelihood of development of AIS decreases. To stop the growth of curves, patients with skeletally immature curves between 25° and 40° should wear a brace, according to the guidelines of the Scoliosis Research Society. Because they run the risk of having their curves continue into adulthood, patients with skeletally immature curves that achieve a magnitude larger

than 45° or patients with skeletally mature curves ≥50° are typically recommended to surgical corrective procedures. [11]

Barcelona scoliosis physical therapy school (BSPTS):

The Barcelona Scoliosis Physical Therapy School (BSPTS) is a physical therapy method known as a plan of sensory-motor therapy, cognitive, and kinesthetic training to encourage and teach patients to improve spinal curvature and postural appearance. Elena Salvá (1926–2007), a Spanish physiotherapist, founded the forerunner to BSPTS in 1968 in Barcelona, Spain. The school followed the Schroth principles and the original intensive inpatient rehabilitation exercise program developed at the Katharina Schroth Clinic in Bad Sobernheim, Germany. It is generally used to treat AIS, specific types of congenital scoliosis, and sagittal deformities such Scheuermann's illness. [12] The BSPTS aims to :1) improve aesthetics and correct scoliotic posture, 2) spinal stabilization and stop curve progression, 3) provide patients and their families with knowledge about the condition and available treatments, 4) improving activity, enhancing breathing, including functional mobility and activities of daily living, 5) enhancing general self-esteem and self-image, and 6) reducing pain. [13]

BSPTS principles are based on the principles of correction that described as following:

1. Deflection, sagittal normalization, and derotation are the three-dimensional postural correction concepts that are employed. Translation, rotation, and combined movements are called sagittal expansions.
2. To get the best correction feasible, the expansion/contraction approach is applied. It makes the process of "corrective breathing" easier. The purpose of the expansion/contraction technique is to use muscle force to widening the trunk in all direction "from inside" (independent of breathing motions).
3. Muscle tension acts as a stabilizer. Whenever the patient could achieve the best correction in any starting position, the therapist instruct patient to exert muscle tension in order to keep the correction. Maintaining the correction throughout this therapy stage, by increasing muscle tension, that will result in an eccentric isometric contraction of the shortened muscles and a concentric contraction of the overextended muscles.
4. Integration. Following the exercise, the therapist instruct patient to relief and relax while still performing self-correction. As much the Patient do exercise more and more -which allow him to maintain best possible 3D correction -as it helps him to keep corrective posture through his daily activities. [14]

International Scoliosis Schroth Therapy (ISST):

The creator of the Schroth technique, Katharina Schroth, had a moderate case of scoliosis herself and get treated with a steel brace until she was sixteen. At that point, she made the decision to create a more practical form to treat herself. Inspired by a balloon, she attempted to selectively

inflate her body's concavities in front of a mirror in an attempt to breathe away the defects of her own trunk. She also made an attempt to mirror the malformation by over-correcting with the aid of corrective positions unique to a certain pattern. She understood that altering postural perception is the only way to acquire postural control. [15] The kinesthetic and sensorimotor concepts reinforce this customized treatment program, which consists of postural self-corrective exercises, postural corrective exercises and postural home exercises. The patient performed it in front of a mirror with repetition. This approach uses rotational-breathing method to reduce torsion of trunk through thoracic respiratory movement toward opposite side, and combines strengthening and stretching exercises, depending on muscle groups imbalance. [16]

Methods:

Study design and population:

This was comparative, randomized, parallel study for successful six months. The study was performed at the out-patient clinic in faculty of physical therapy at Kafr El-Sheikh University. The study was harshly adhered to the criteria announced in the newest version of the Declaration of Helsinki code of ethics.

Sample size and power analysis:

A preliminary investigation was conducted to choose an appropriate sample and avoid type II error. The G*Power software 3.1.9.2 (Neu-Isenburg, Germany) [F tests- ANOVA, $\alpha = 0.05$, $\beta = 0.2$] determined that a preliminary study conducted to analyze the effect of the proposed interventions on functional balance required a sample of 32 subjects (16 in each group) to obtain an actual power of 0.83 and an effect size of 0.52. As a result, we enrolled up to 40 youngsters to allow for probable withdrawal rates, and 30 finished the treatment. The flowchart for the study is shown in Fig. 1.

Patients:

Patients with single right thoracolumbar AIS, varying in age from 12 to 15 years, were registered in this study. The admission criteria included: not participating in other treatments during the study, angle of scoliosis < 25°, Risser sign of Π-V, and not using muscle relaxants or braces.

The exception criteria included: scoliosis caused by congenital, neuromuscular, or syndromic etiology, cardiac anomalies, kyphosis, true leg length discrepancy, asthma and other pulmonary diseases.

Randomization, Allocation, and Blinding:

Constrained stratified randomization scheme was performed to achieve balance across the two treatment groups (BSBTS and ISST groups) to allocate 30 children (15 for each group).

Both groups underwent treatment plans lasted for six months, three days a week, for one hour a day from 14 May. 2023 to 30 June 2024.

Assessment:

The same blinded researcher performed all measurements for all patients in both groups under the same circumstance just before and after successive six months of treatment. Cobb's angle and angle of trunk rotation (ATR) measurements are carried out as outcome measures.

Cobb's Angle:

An anterior-posterior whole spine and pelvic plain X-ray taken while standing will be used to calculate the Cobb's angle and the Risser sign grade. The follow-up will be handled by a radiology specialist who has been blinded to the patients' allocation.

Angle Trunk Rotation (ATR):

A scoliometer will be used to measure Angle Trunk Rotation (ATR). The radiography measures and the scoliometer measurements correlated well. The patients will be told to undress, take a seat, and bend their trunk forward so that their hands and head are between their knees, maintaining their elbows and shoulders straight. The mid-thoracic region (thoracic 6 to thoracic 8) was used to measure ATR.

Risser sign:

First identified in 1936, the Risser sign is a commonly used radiographic marker that can be used to forecast growth potential in an image of the entire spine taken on the same scan [(17)]. A uniform information sheet with pictures of each stage and a detailed explanation of Risser staging was provided to each grader. Stage 0 denotes no iliac crest apophysis ossification, stages 1: under 25% of ossification, stage 2: over 25%-50% of ossification, stages 3: over 50%-75% of iliac crest ossification, stage 4: over 75% of ossification, and stages 5: complete fusion and ossification of the iliac apophysis, represent varying degrees of apophysis excursion. [(18)]

SRS-22 patient questionnaire:

The SRS-22 uses 22 questions to assess quality of life across five domains. Pain, image/appearance, function/activity, mental health, and treatment satisfaction are these five dimensions. On a scale of 0 (worst) to 5 (best), each question received a score. The overall score was computed. An improved quality of life was indicated by a high score. [(19)] Despite the Scoliosis Research Society-22R instrument was designed at first as a disease-specific instrument to asses' quality of life in patients with AIS, it also has been extended for spinal deformity in adult patient. Research has demonstrated that it is valid, dependable, and adaptable to changes in adult patients with spinal deformities (ASD). [(20)]

Methods:

BSPTS:

The patients in the BSPTS group began their exercise regimen under the physiotherapist supervision. To optimize correction and attain trunk symmetry, the BSPTS exercises were executed in an asymmetrical posture. To preserve vertebral alignment, these activities include stretching, strengthening, de-rotation, de-flexion of the spine, and rotational breathing techniques. The Schroth-based exercises were recommended based on the individuals' capacities and curve patterns. Five BSPTS-based exercises were carried out by participants in a range of situations, including supine, sitting, side lying, prone, and standing.

ISST:

Therapist instructed patient to breathe as deep as he can, aiming for maximal chest wall expanding during the self-correction of the curve. During expiration, therapist instructed patient to keep all corrections aiming to increase the muscle activation. The exercises are programmed as follows:

- Warm up (four sets × six repetitions): the therapist makes mobilization and flexibility to the thoracic curve as rib hump derotation, stretch to left side and ventral Prominence derotation in different positions as supine, prone and sitting.

- side lying Position: (four sets × six repetitions): The patient lies on his or her right side with a roll providing passive support beneath the curve's peak. There was additional roll under the shoulder to straighten the thoracic region's curve. While the other limb was positioned with its elbow bent in front of the chest, the left upper limb (UL) was hoisted overhead and straightened. The right lower limb (LL) was placed on the floor with its hip and knee 90 degrees flexed. Each pelvis was kept in a perpendicular position to the other. The left LL was stretched out and rested on a stool. By moving the convex side toward the concave side, the patient was instructed to self-correct the curve.

- Sitting on a ball (four sets × six repetitions): The patient performed this exercise. While the right UL was at a little flexion of about 135° and holding the bar above shoulder level, while the elbow joint is semi flexed, the left arm was abducted horizontally and held the wall bar at the shoulder level with a semi flexed elbow. Therapist instruct the patient to move convex side toward the concave side, to apply self-correction of the curve.

- Shoulder counter-traction in prone (four sets × six repetitions): from lying prone, the lumbar curve was adjusted by activating the iliopsoas muscle, while the thoracic curve was adjusted by shoulder counter-traction.

- Muscle cylinder in standing (four sets × six repetitions): The exercise was designed to assist straighten the lumbar curve by activating the quadratus lumborum on the lumbar concavity.

While the left LL placed in abduction and stretched out on a stool, patient stood on the right LL. Left hand grasped the hip. Right UL was raised to meet the opposite LL that had been abducted.

- Cool down (four sets × six repetitions): To put the pelvis in a posteriorly tilted posture, the patient was lying crook-wise. The patient was instructed to repeatedly move their thoracolumbar junction forward while breathing normally. The investigator sensed a developing movement and supported the spinal processes.

Results:

Statical analysis:

Analysis of Variance (ANOVA) was performed in Statistical Package for the Social Sciences (SPSS, 20). The data were tested for normality before analysis. Patient characteristic (Age) with groups were performed by T-test and Chi-square was used to comparison between Risser sign and groups. All statistical tests were conducted with a significance level of $p < 0.05$.

Basic Characteristics of the patients:

The gender distribution for each group illustrated in figure (2). Sex ratio was one male (7%) to 14 females (93%) for BSPTS group, while it was four males (27%) to 11 females (63%) for ISST group. The results of P-values for age and RISSER sign were more than 0.05, indicated no significance between the two tested groups. RISSER sign was 20, 60 & 20 % for II, III & IV respectively for the two tested groups table (1).

Age was expressed by Mean ± SD, sex as ratio and RISSER sign as number (%). ^{NS} $p > 0.05$ = non-significant, ^{S} $p< 0.05$ = significant.

Effect of treatment on COBB'S and ATR angles:

Within-Group Comparison:

A significant decrease was noted in ATR and COBB'S angles for the two tested groups ($P<0.001$) that the treatment is effective in each group separately (table.2).

Between-Group Comparison:

Data in table (2) and figures (3 & 4) illustrated that is no significance difference between the two tested groups (BSPTS & ISST) according to ATR pre-treatment (P=1.00) and COBB'S ANGLE pre-treatments (P=0.826). The ATR post-treatment between the groups show significance that P=0.004; the ATR post-treatments show response for BSPTS group more than ISST group. The COBB'S angle post-treatments (P=0.059) show no significance difference between the two tested groups.

SRS-22 questionnaire:

SRS-22 questionnaire overall score pre-intervention was 83.2 (62 to 96) with sub-domains pain 23.1 (20 to 25), self-image 19.2 (13 to 23), mental health 18.1 (12 to 25), and function 22.6 (17 to 25). A statistically significant improvement was observed post-intervention of both groups separately in overall score (90.3, 69 to 99, P=0.008), self-image (21.2, 14 to 25, P=0.03), mental health (20.6, 15-25, P=0.005). Improvement without statistical significance was obtained for pain (23.8, 20 to 25, p= 0.09) and function (23.5, 20 to 25, P=0.06), while the treatment satisfaction was excellent (9.2, 7 to 10).

The success rate of the treatment:

As illustrated in table (3) the BSPTS group showed more response treatment achieved average improvement 30.51±10.32% for ATR angle with minimum 18.18% and maximum 50.0% and 25.98±8.52% for Cobb's angle with minimum 15.79% and maximum 42.11%. The ISST group showed less response to treatment achieved average improvement 16.18±6.26% for ATR angle with minimum 9.09% and maximum 30% and 18.23±3.16% for Cobb's angle with minimum 13.04% and maximum 26.32%.

Discussion:

The aim of this paper is to discuss the ISST and BSPTS approaches and their effect on AIS to enrich our knowledge with the best way of conservative management for AIS patients. This would help physical therapist to integrate the most effective elements from each into their practice.

As there isn’t any previous study comparing between effect of BSPTS and ISST in treating AIS, this will be the first of its kind to discuss or determine the preference of one school over another.

Our study results refer to the BSPTS method and ISST method are both effective in preventing or decreasing the scoliosis progression, the cobb’s angle and ATR which in its turn improve postural appearance and enhance centralization of the spine providing more confidence to the patient about its appearance. But also it seems that BSPTS has upper hand or more improvement rate in managing AIS than ISST. This results is because the ISST uses self-elongation and active correction to the curve while BSPTS uses active and passive elongation using belts and active correction and passive correction using therapist hands which improve the result of mobilization and increase amount of 3D correction leading to better results. Adolescent scoliosis accounts for over 90% of all occurrences of idiopathic scoliosis, hence the patient age range was selected accordingly. If left untreated, AIS can progress to significant trunk abnormalities that compromise thoracic capacity, biomechanics, exercise capacity, and overall fitness, all of which have an influence on quality of life. AIS has received a lot of attention because of its effects on young people's physical, psychological, biomechanical, neuro-motor, and cardiorespiratory functions. [21]

The result we got using BSPTS method in group 1 showed response to treatment with achieved average improvement 30.51% for ATR angle and 25.98% for Cobb's angle which consider a great improvement in AIS during six months. The BSPTS approach is focused on strengthening exercises tailored to each scoliosis patient and their distinctive curvature. Katharina Schroth invented the unique rotating angular breathing (RAB) exercises, which aid in vertebral and rib cage derotation as well as increased vital capacity. This unique breathing technique causes the ribs to inflate from within the rib cage in "sideways and backwards" directions, allowing the vertebrae to return to their original, untwisted posture. The activation of core muscles such as the iliopsoas, thoracic and lumbar fascicles of the erector spinae, and quadratus lumborum helps to stabilize and maintain the inflated ribs and derotated vertebral bodies. Encouraging movement and flexibility helps to relieve stress and aid in postural correction. Karina A. Zapata [(22)] concurred with our study, which adds to the body of data in favor of PSSE for AIS. Specifically, our study focused on skeletally immature AIS individuals with mild scoliotic curves and used an outpatient model that employed the BSPTS approach. Schreiber, S. [(23)] found that after six months, participants' curves, which had been averaging 28° to 29° at baseline, improved 1.2° in the BSPTS group and deteriorated 2.3° in the control group. Kim, K. D. [(24)] gave PSSE treatments to patients with idiopathic scoliosis for 12 weeks, three times a week, which is consistent with our study. The results showed a 49% decrease in Cobb's angle of thoracic curve, from 23.6° to 12°. The current study's trend is in line with these earlier findings, showing that during eight-week treatment, the Cobb's angle of lower thoracic curve reduced by almost 22% while the angle of upper thoracic decreased by roughly 6%. Studies showed that the BSPTS school is positively effect in decreasing the progression of scoliotic curves. In a one-year study by Zapata K.A and co-authors [(25)], the group that applied BSPTS, achieved best results in stabilizing Cobb's angle more than the observation group. in six-month study, Schreiber et al. found the Schroth method achieved a remarkable reduction of cobb's angle of scoliotic curves [(26)]

In the ISST group's reaction to treatment the ATR and Cobb's angles indicated an average improvement of 16.18% and 18.23%, respectively. Similar to Otman's study [(27)], after six months and a year of Schroth exercise therapy, the Cobb angle reduced by 6.85° and 8.25°, respectively. To improve joint mobility prior to the workouts, the ISST approach incorporates spine mobilization and flexibility between ribs. Muscle activation occurs by the activation of specific muscles that can aid in correction, such as the iliopsoas, quadratus lumborum, and erector spinae. In their study, Negrini et al. [(28)] found that the ATR rose 0.15° in the control group (conventional physiotherapy) and decreased 0.33° in the PSSE group. According to Tuğba Kuru findings [(29)], the training group's mean Cobb angle fell by 2.53°. It aims to improve balance of posture and minimize scoliosis curve by strengthening intercostal muscles and encouraging diaphragmatic and respiratory muscle normalization. As Sanja Schreiber's randomized controlled study [(30)] results demonstrate that patients with AIS with curves larger than or equal to 45 had the benefits of the Schroth PSSE intervention added to standard therapy (monitoring or bracing).

In study of 8 weeks of ISST, proved more effective than conventional exercises at increasing lung capacity, chest expansion, muscle strength, and beneficial changes in chest expansion and spine angle. [31] Also, in study by (Orban & Horvat, prove that Schroth method applied in one-year individual program positively effects on improvement of the scoliotic patients with Cobb angle more than 45°. [32] Depending on the severity of the curve, scoliosis can cause a variety of medical and mental difficulties, as well as a lower quality of life. [33] In our study, children diagnosed with AIS and treated conservatively showed quality of life improvement, which assessed the quality of life in adolescents with the SRS-22, reported that there was a change in the quality of life scores of the two groups after a six-month follow-up, and change was improved in self-image and pain, but other. Domains of the SRS-22, such as function and total quality of life, showed no significant differences when compared to routine care alone. In the study by Kuru et al. [29], although scoliosis-specific measures like the Cobb angle showed improvements, no significant change in overall quality of life was detected. However, minor gains in the self-image subdomain were observed, suggesting that while Schroth therapy may have limited overall impact in some cases, it still plays a role in improving self-perception. Our study has some limitations, first of all, it focuses on adolescent idiopathic scoliosis and ignoring other types of scoliosis as juvenile and adult scoliosis then generalized the results to other type of scoliosis. Second, although of all research, the studies found that have common measures except for cobb angle which is relatively small.

Conclusion:

The BSPTS and ISST methods both have an effective result in managing AIS and in reducing curve progression. However, BSPTS has upper hand on ISST in managing AIS and improvement of cobb angle and ATR. As BSPTS group has better improvement percentage. Future research should aim to further explore the long-term benefits and optimize treatment protocols for this population.

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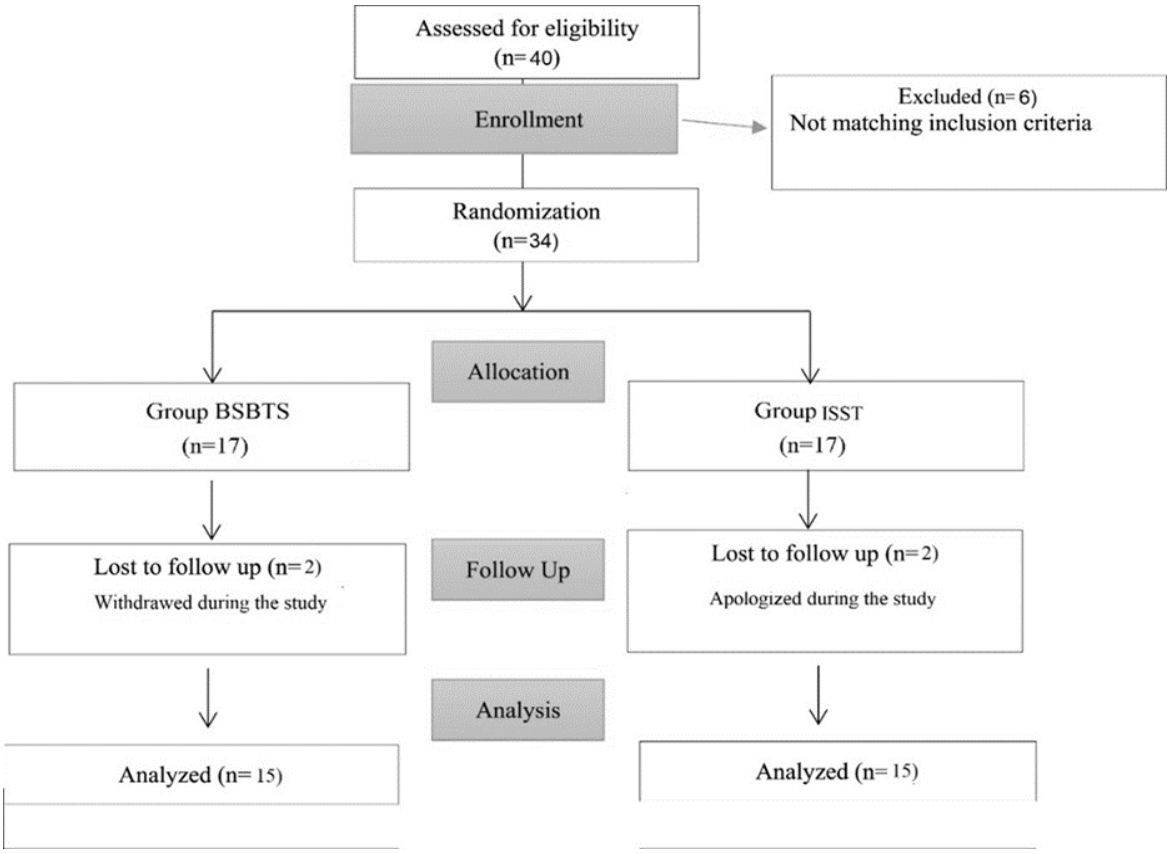

Figure 1. flow chart.

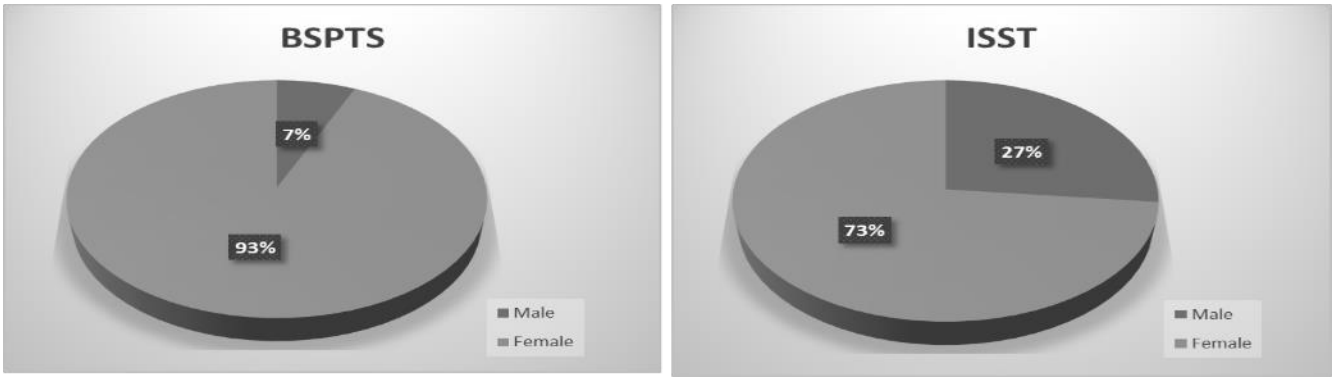

Figure 2. Gender distribution of ISST and BSPTS groups.

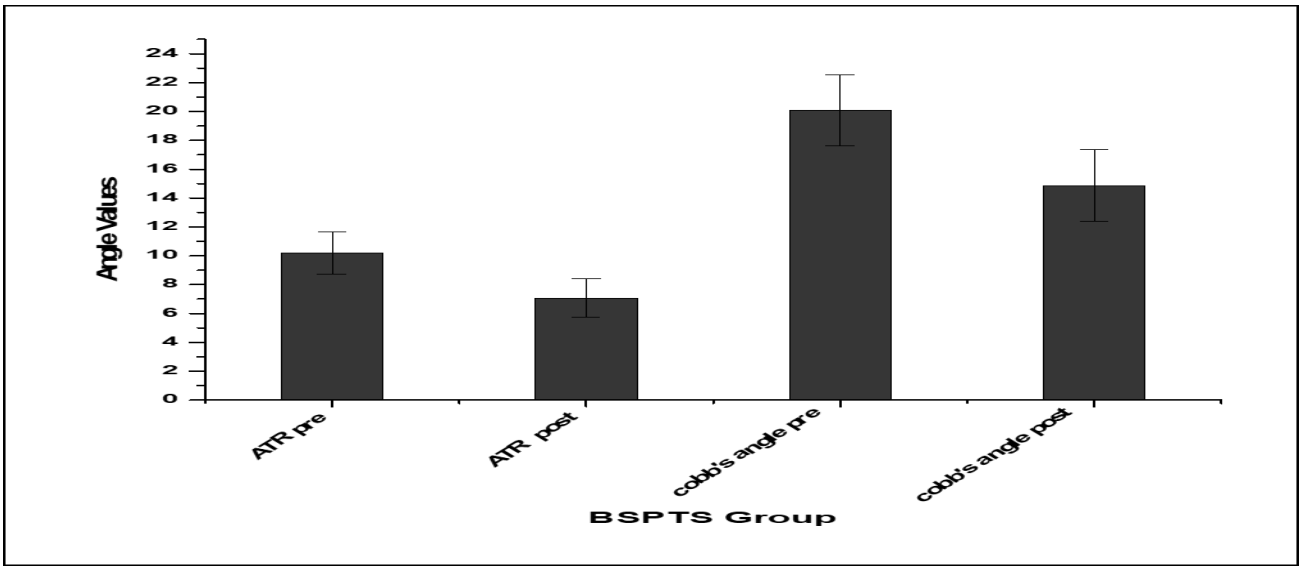

Figure 3. Comparison of ATR (pre & post-treatment) and Cobb's (pre & post-treatment) for BSPTS group.

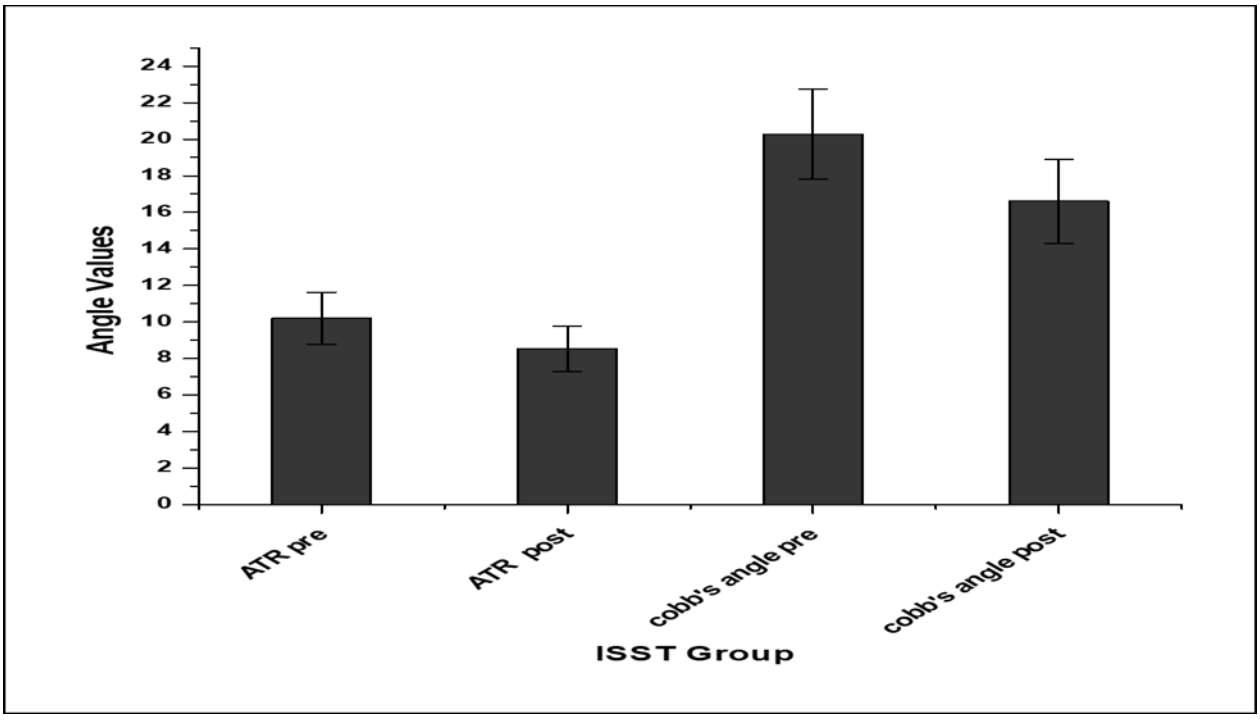

Figure 4. Comparison of ATR (pre & post-treatment) and Cobb's (pre & post-treatment) for ISST group.

Tables:

Table 1. comparison between BSPTS and ISST groups according to age, sex and RISER sign.

	GROUP BSPTS (N=15)	GROUP ISST (N=15)	P-VALUE
AGE	13.7±1.1	13.5±1.06	0.618^{NS}
SEX	1 M : 14 F	4 M : 11 F	
RISER SIGN			
II	3 (20%)	3 (20%)	
III	9 (60%)	9 (60%)	0.65^{NS}
IV	3 (20%)	3 (20%)	

Table 2. comparison between BSPTS and ISST groups according to ATR pre & post treatments and COBB'S ANGLE pre & post treatments.

	GROUP BSPTS (N=15)	GROUP ISST (N=15)	BSPTS VS. ISST P-VALUE*
ATR			
PRE-TREATMENT	10.2±1.47	10.2±1.42	1.00^{NS}
POST-TREATMENT	7.07±1.33	8.53±1.25	0.004^{S}
P. VALUE**	$P < 0.001^{S}$	$P < 0.001^{S}$	
COBB'S ANGLE			
PRE-TREATMENT	20.07±2.46	20.27±2.46	0.826^{NS}
POST-TREATMENT	14.87±2.5	16.6±2.32	0.059^{NS}
P. VALUE**	$P < 0.001^{S}$	$P < 0.001^{S}$	

Table 3. the improvement rate (%) of the two tested groups according to the success rate of the treatment

	BSPTS GROUP		ISST GROUP	
	ATR%	cobb's%	ATR%	cobb's%
MIN	18.18	15.79	9.09	13.04
MAX	50	42.11	30	26.32
MAIN	30.51	25.98	16.18	18.23
SD	10.32	8.52	6.26	3.16