CASE SERIES

Outcome observations in patients using a scoliosis activity suit: A retrospective chart review after one-year follow-up.

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ABSTRACT

Objective: Non-surgical treatments for idiopathic scoliosis have shown tenuous results in the literature. Among non-surgical options, bracing has been the most studied. Although many bracing studies have shown positive results, problems with compliance, construction, and follow-up make the true value of bracing difficult to discern from observation or exercises. This study illustrates the use and results of a novel activity suit use for idiopathic scoliosis.

Clinical Features: A total of 62 patient records with a history of idiopathic scoliosis were retrospectively selected from a single multidisciplinary medical clinic.

Intervention & Outcomes: Patients were fitted for a scoliosis activity suit which was worn for one year. Outcome measures were collected at baseline and at one year to evaluate progress. Improvements in Cobb angle and angle of trunk rotation (ATR) were observed in all patient categories except for adolescent double major curves. Self-rated improvements in pain and daily function were observed in all adult patient curve patterns. Scoliosis correction was observed in 48% of the entire cohort, with 42% of curves stabilized or unchanged after one year. A combined total of 6 patients failed the treatment.

Conclusion: Although short term treatments for scoliosis have resulted in positive outcomes, none of these changes have been supported by long-term follow-up studies. Scoliosis treatment involving chiropractic rehabilitation should focus on obtaining long term outcomes for skeletally immature patients, and avoid reporting only short term outcomes in both the adolescent and adult scoliosis populations.

Key Words: Chiropractic; Exercises; Posture; Rehabilitation; Scoliosis

Introduction

Bracing for juvenile and adolescent idiopathic scoliosis has a long history of use. Effectiveness of conventional rigid bracing is highly variable, likely depending upon the skill of the practitioner, the type of brace selected, and the type of scoliosis being treated. In review of various bracing studies, Dolan and Weinstein found that bracing does not result in superior clinical outcomes compared to observation only[1]. Another review by Negrini et al[2] found that bracing studies were generally of low methodological quality, and therefore their effectiveness remains in question.

Various studies have sought to compare the effectiveness of different types of scoliosis bracing. Janicki et al[3] compared the TLSO to the Providence brace and found the Providence brace to provide superior correction for curves below 35°. However, the effectiveness of both braces was called into question by the authors. Another study by Howard et al[4] found the TLSO to be superior to the Charleston and Milwaukee braces. Katz et al concluded that the Boston TLSO should be recommended over the Charleston brace as well[5]. European bracing has been given more exposure in recent years, however, comparisons between these braces are lacking[6].

A dynamic brace, the SpineCor brace, has been repeatedly tested in the literature[7-11]. Its results have ranged from providing correction[8,9], stabilization[7], to providing no benefit compared to natural history[11]. The SpineCor has been compared to the SPoRT brace[12] as well as the Cheneau brace[10]. Both studies provided evidence that the SpineCor brace did not achieve the same benefit as its rigid counterparts.

Regardless of which style of brace is used, they all work by the same generalized principles. Bracing is intended to force the spine into a corrected position, and acts as a barrier to keep the spine in that corrected position as long as the brace is worn. This goal is based upon the Hueter-Volkmann principle, which essentially states that if vertebral endplates can be unloaded on the concave side of the scoliosis, remodeling of the vertebral shape will occur and prevent curve progression[13]. Therefore, bracing is only recommended as a standard of care for patients with skeletal growth still remaining[14]. In this study, I introduce the concept of a neuroreactive scoliosis activity suit, and compare its method of use to conventional rigid and dynamic bracing for the treatment of scoliosis.

History of the Scoliosis Activity Suit

The concepts behind the scoliosis activity suit were born out of the neuromuscular re-education concepts taught within the Pettibon System, a chiropractic treatment system centered around the neurophysiological pathways associated with posture modulation and control. Within this system, a core component is the Pettibon Weighting System™, which is composed of a series of external head, torso, and pelvic weighting designed to elicit specific postural responses that are measurable both by visual posture and by comparative radiography. This external weighting system has been the focus of, or part of, several previous studies[15-22]. This weighting system works primarily by stimulating translational posture adaptations, which can be predicted based upon the patient's baseline posture and/or radiographs. While these translational effects have shown promise for patients with scoliosis[15-21], scoliosis is a rotational deformity, and translational forces are not always well-received by the scoliotic spine. As the degree of scoliosis increases, increasing compressive forces diminish the ability of translational corrective responses to be sustained. Translational postural changes may also result in increased immobility and accelerated degeneration of the intervertebral discs if the spine abnormally rotates further to compensate for the translational change[23], which is a common phenomenon in conventional bracing. Therefore, the activity suit was designed with the goal of creating a rotational resistance to which the postural reflexes and associated axial musculature must adapt. These rotational adaptations are measurable via visual posture analysis as well as comparative radiography.

Activity Suit Descriptions

The activity suit is a neoprene wrap-based activity suit. The activity suit is composed of 4 separate pieces. The main piece, the Anchor, is the wrap that fits around the patient's thigh. The Lumbar piece attaches directly to the Anchor, and their configuration is dependent upon the location of the lumbar or thoracolumbar curvature. The third piece is called the Torso piece, and looks like a half-tank top shirt that acts upon the thoracic curvature. The fourth and final piece, or set of pieces, are the tension straps. The tension straps connect each of the first three pieces together in a rotational pattern, which introduces a variable amount of rotational force into the patient, to which he or she must react. These tension straps may be long or short. The longer tension straps are more elastic and provide more rotational resistance to which to resist.

The shorter straps provide more of a barrier type resistance and are less rotational. Figure 1 depicts each of the activity suit pieces.

Theoretical Applications

The scoliosis activity suit functions with dual purposes. In comparison to rigid or dynamic bracing, the activity suit may be worn with a goal of providing a barrier-type corrective effect. This is termed as the Supportive mechanism. This mechanism is intended for providing a guided growth stimulus for skeletally immature patients, or for adult patients looking to an activity suit to improve their pain levels and/or their activities of daily living.

The second purpose is referred to as the Reactive mechanism. This mechanism is unique to the activity suit and involves creating rotational resistance into the torso that accentuates the rotational displacement of the scoliosis. This increased rotational stimulus is believed to place a slow stretch on deep spinal muscles into the direction of scoliosis rotation, thus eliciting a corrective reflex that causes the same muscles to activate and result in counter-rotation of the spine out of the scoliosis pattern. This mechanism is designed for skeletally immature patients who need increased torso stability, patients who display biomechanical factors suggestive of scoliosis progression, or patients who clinically demonstrate normal or above-normal spinal flexibility. This activity suit is typically performed for a maximum of up to 30-40 minutes per session, and each patient is monitored to assess endurance level.

Methods

Charts of patients who presented to an integrative medical center with a chief complaint of scoliosis were retrospectively selected for study. Skeletally immature patients with a diagnosis of adolescent idiopathic scoliosis, and adults diagnosed with adult degenerative scoliosis, were included in this study. They must have also completed one year of scoliosis management, and used the scoliosis activity suit as part of that management. Patients were excluded if they had juvenile idiopathic scoliosis, scoliosis secondary to a genetic disorder or developmental disorder (i.e. cerebral palsy, autism), or scoliosis due to vertebral deformity (hemivertebra, spina bifida). Based upon these criteria, a total of 62 patient files were selected. All patients whose files were selected, or their parents, signed HIPAA-approved informed consents to publish their data.

At baseline, multiple data were collected for outcome assessment. Radiological data included scoliosis measured via Cobb angle, apical rotation, and apical midline deviation. For purposes of this study, only Cobb angle is reported. Other data include the angle of trunk rotation (ATR), while pain and daily activities were measured using the quadruple visual analog scale and the functional rating index, respectively. Once baseline measures were obtained, patients were fitted for the scoliosis activity suit based upon their curve pattern, thoracic, lumbar, thoracolumbar, or double major.

Figure 2 illustrates some typical activity suit configurations for each of the basic curve patterns. Once patients were fitted, AP scoliosis radiographs were taken to compare the corrective potential of the activity suit to baseline. To serve as a guide, a minimum of 10% Cobb correction in the activity suit was recommended for the patients to begin using the activity suit.

After initial correction was verified, patients were trained on putting on the activity suit, and instructed to wear the suit for 1-2 hours per day for the first month, and gradually increasing to 4-6 hours per day over the next 90 days. However, only standing, upright time was counted toward the 4-6 hour total. Since the thigh is the foundation of the activity suit, the patient needed to be weight bearing in order for the suit to provide a corrective anti-rotational effect. Patients were encouraged to continue all of their normal daily activities. Patient followed up one month after beginning the suit, and then at 4 months, 7 months, 10 months, and finally 12 months. At each follow-up appointment patients were asked to provide an estimate of their wear time over the previous time period. Except for radiographs, outcome measures were collected at 7 months and 12 months. Before the 12 month appointment, patients were asked to not wear the activity suit for the entire day before coming in for their appointment. From follow-up patient radiographs, Cobb angle, apical rotation, and apical midline deviation were measured and recorded. A survey was also completed by each patient in regards to the comfort of the activity suit as well as their logged wear time. The survey asked about the comfort level of the activity suit. There were four possible answers, including 'Poor,' 'Fair,' 'Good,' or 'Very Good.' Parents were also asked to estimate the approximate average hours per week that their children wore the activity suit.

Results

The total patient sample was divided into two groups, based upon skeletal maturity. Those patients with a Risser sign of <5 were put into one group, labeled Immature, while those with Risser 5 comprised the second group, labeled Adult. Each group was further subcategorized according to their respective curve patterns: *Thoracic, Lumbar, Thoracolumbar, and Double Major*. All calculated values were performed relative to each of these groups and subcategories. In all 62 patients,

For the Immature group, Table 1 shows all of their collective outcome assessments data. A total of 26 patients comprised the Immature group. The average age of this group was 13 years. The average initial starting Cobb angle was 31°±13, while the ATR averaged 12°±5. Initial average baseline QVAS and FRI scores were 7±4, and 3/40. After subcategorizing patients according to curve pattern, Thoracic patients had the following baseline values: 1) Cobb angle of 33°±7; 2) ATR of 13°±2; 3) QVAS of 6±4; 4) and FRI 6/40. These same outcomes measures in Immature Lumbar patients were 26°±11, 9°±3, 11±4, and 5/40. For the Thoracolumbar group, initial Cobb angle was 43°±10, ATR measured 8°±3, while the QVAS and FRI were 6±2 and 8/40. Finally, the Double Major group had average starting Cobb angles of 35°/30°, ATR of 11°±5, QVAS of 3±2, and FRI of 2/40.

After one year of wearing the activity suit, improvements were observed for both groups within different parameters. Table 2 shows the comparative Cobb measures for each subcategory at baseline and at one year. For this group, 16 of the 26 patients obtained a Cobb angle correction of greater than 6°, while 6 of the 26 patients remained within 5° of baseline. Four patients saw their curves increase more than 6°. Specifically, Immature patients had an average Cobb angle of 27°±9, ATR of 10°±5. However, there were differences observed within this group in the levels of improvement depending upon the curve type. For example, thoracolumbar curves improved to an average of 28°±8, thoracic curves improved to 22°±10, and lumbar curves improved to 20°±7. However, double major curves improved only slightly to 32°/28°, which did not reach the minimum 6-degree standard of change to be classified as correction by the Scoliosis Research Society Committee on Non-Operative Treatment[24]. Except for the QVAS and FRI scores in the Immature Thoracolumbar and Lumbar groups, QVAS and FRI changes did not reach statistical significance for any of the remaining curve types.

The Adult group had an average age of 47 years, comprised of 36 patients, and an average baseline Cobb angle of 54°±15. These values are summarized in Table 3. The average initial ATR was 14°±9. Average baseline scores for the QVAS and FRI were 47±19 and 14/40, respectively. Within this group, the Thoracic patients had the following starting values: Cobb angle of 43°±12, ATR of 16°±7, QVAS of 37±6, and an FRI of 12/40. Lumbar patients had initial values of Cobb angle 58°±10, ATR of 11°±6, QVAS of 57±9, and FRI of 19/40. The Thoracolumbar group had an initial average Cobb angle of 48°±8, ATR of 8±3, QVAS of 53±11, and FRI of 17/40. The Double Major group has curves of 55°/51°, ATR of 12°±11, QVAS of 23±4, and FRI of 10/40.

The improvements reported and observed in the Adult group differed from the Immature group. A total of 14 of the 36 patients saw their curvatures decrease more than 6°, while 20 of them remained within 5° of baseline. Two patients within this group had curves that increased over this time period. This group saw an average one year Cobb angle of 44°±8, and ATR of 11°±9. Within the Adult group, the Double Major curve pattern was the most resistant to change, decreasing slightly to 49°/49°. The Lumbar group, by contrast, produced the largest improvement, decreasing to Cobb angle of 38°±13. This was followed by the Thoracolumbar group with an average one year Cobb angle of 35°±6, and Thoracic group of 34°±12. The Cobb angle and ATR values are shown for each curve type in Table 4. Observed changes in QVAS and FRI scores were also more significant in the Adult group, with an average one year QVAS score of 30±9, and FRI score of 6/40. Based upon the SRS criteria for Cobb angle changes[14], a correction of the scoliosis was observed in 48% of the entire cohort, with 42% of curves stabilized or unchanged after one year. A combined total of 6 patients failed the treatment, defined as progression of the curve greater than 6° over the year.

Discussion

Overall, Immature patients typically reported an acceptable level of comfort while wearing the activity suit, claiming "Good" or "Very Good" 73% of the time, while Adult patients responded "Good" or "Very Good" 86% of the time. Some of this reported difference between the two groups may be the perception of the word 'comfort' as brace wearing in adolescence often raises concerns of self-image and body appearance. It may be that adult patients are less concerned about their appearance in the activity suit if it is providing at least a clinically significant benefit.

When broken down into specific curve patterns, those patients with a single thoracolumbar scoliosis typically saw the greatest improvement in radiological parameters, with double major curve patterns showing the least improvement. This is consistent with previous data on chiropractic rehabilitation where single thoracolumbar and double curve patterns showed most and least improvements, respectively[18]. However, the improvements in this study are comparable to the level of improvements reported in other studies on the same curve pattern and similar patient populations[15,18].

When looking at age groups within this patient sample, younger patients tended to achieve bigger reductions in curve size compared to older patients. However, the lesser changes experienced by older patients were also reported with bigger concurrent improvements in pain and activities of daily living. In contrast, postural changes occurred more significantly in adult patients. This is an interesting result considering that younger patients are typically more flexible. However, perhaps this flexibility allows for a molding effect while wearing the activity suit that is at least somewhat undone when the activity suit is taken off. However, adult patients also wore the activity suit slightly more per day than the younger patients.

Limitations

There are specific limitations that need to be addressed in this study. First, there is no control group in this study. Therefore, specific attributions to treatment cannot be made. Secondly, there was no objective tracking method employed to evaluate wear compliance among the patients. Wear time was based only upon what the patients verbalized to me. Therefore, there may be some unknown variability between what was reported and what was actually done. Finally, because the adolescent patients in this study were not risk-stratified by genetic testing, it is possible that at least some of them may have seen their curvatures stabilize or improve over time as a result of natural history and growth. Future studies should aim to better quantify compliance rates, as this has been a barrier to maximal effectiveness in conventional bracing protocols[25].

As mentioned earlier, because the base of the activity suit is the thigh, the patient must be weight bearing in order for the suit to exert its corrective effects. This limits the amount of time the average person can wear the suit and gain a positive benefit from it. This is in contrast to rigid or dynamic bracing where the patient can wear these virtually constantly, 18-23 hours per day.

According to the natural history of progressive scoliosis, curves may increase 1-2° per year even into skeletal maturity in both adolescent idiopathic scoliosis as well as adult degenerative scoliosis[26]. Because of this, all of the patients who fell into the category of stabilization (±5°) may well be within the tolerance of the course of natural history. The only way to discern who was truly stabilized and those who were simply progressing consistently with natural history will be to continue to follow these patients for five years or more, thereby eliminating the potential for natural history findings to be collected synonymously with stabilized curves.

Conclusion

Idiopathic scoliosis was stabilized or corrected in 90% of a retrospective cohort of 62 patients wearing a neuroreactive activity suit for one year. Single thoracic and thoracolumbar curves seemed to respond best to the suit, with double major curves showing the smallest average improvement. This activity suit may be an alternative option for patients who demonstrate noncompliance with full-time conventional rigid and/or dynamic bracing, due to its reported comfort and reduced wear time. Follow-up studies should include the use of this activity suit in concert with scoliosis rehabilitation exercises versus wearing the activity suit alone. This study adds to the growing body of exercise-based scoliosis treatment literature that documents multi-dimensional outcome assessments.

Competing interests

The author (MWM) has a patent pending on this activity suit in the USA.

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Figure 1

This figure illustrates the pieces that comprise the scoliosis activity suit. From left: Anchor, Torso, Lumbar, and Tension Straps. Also available, but not shown, are shorter tension straps.

Figure 2

Figure 2 depicts some sample configurations of the activity suit.

Figure 3

Figure 3 shows some sample postural and radiographic changes that results from wearing the activity suit

Table 1   Immature Group Averages

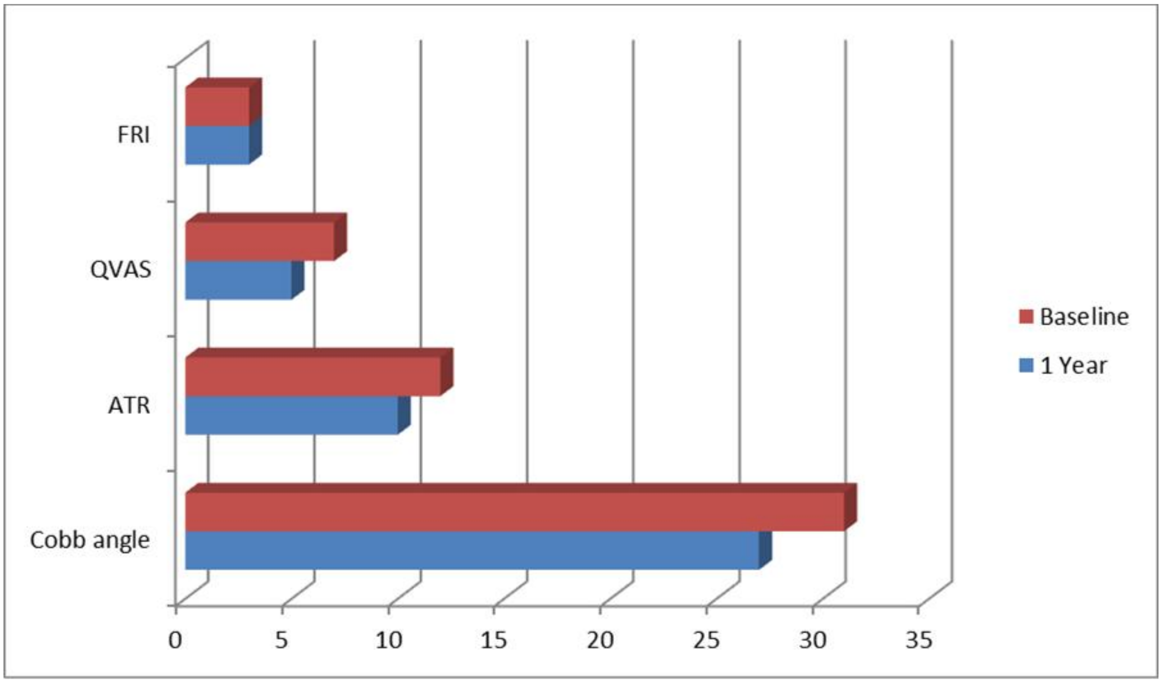


Table 2   Immature Subcategories

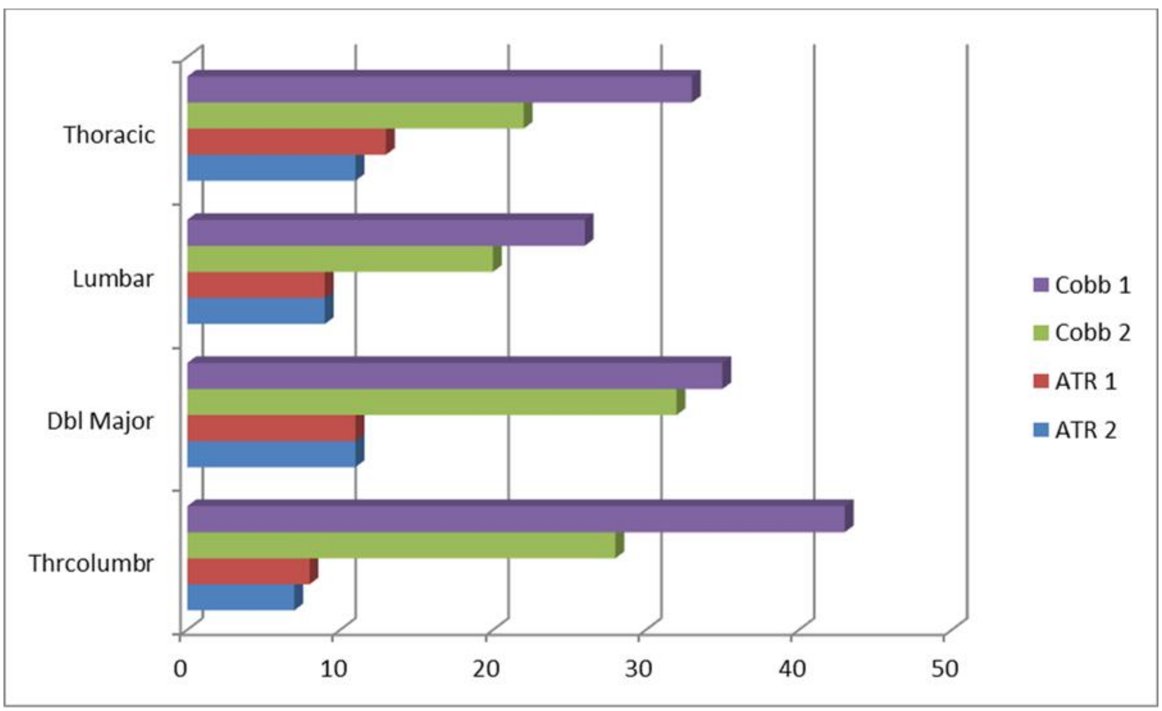


Table 3 Adult Group Averages

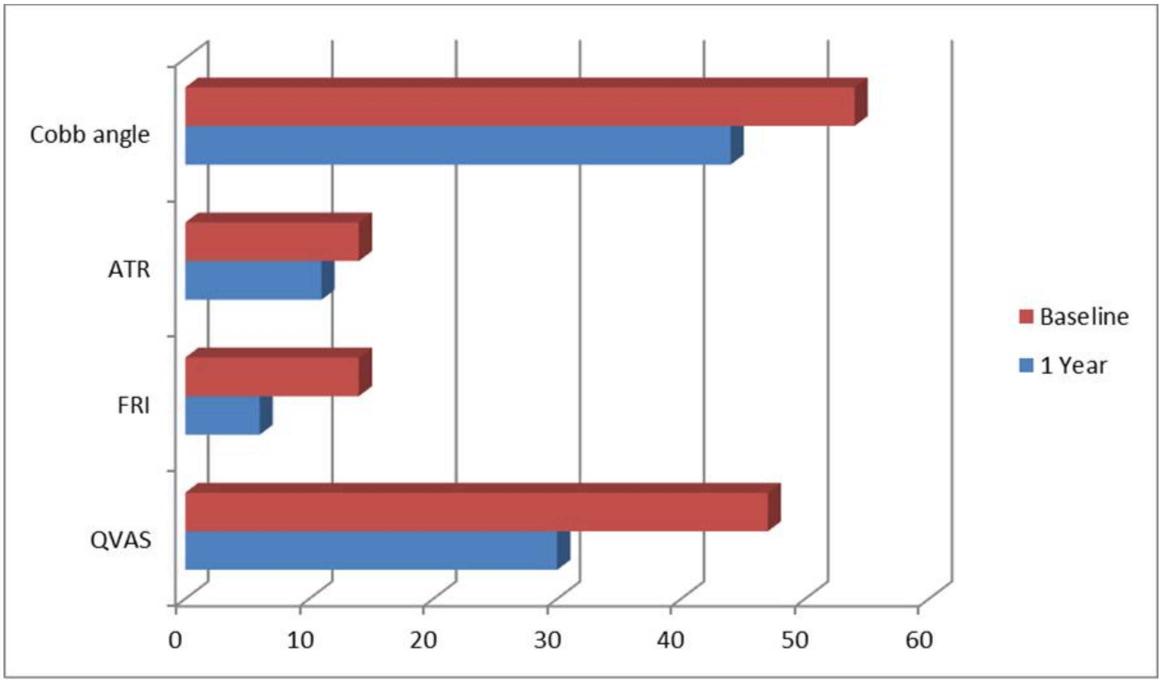


Table 4 Adult Group Subcategories

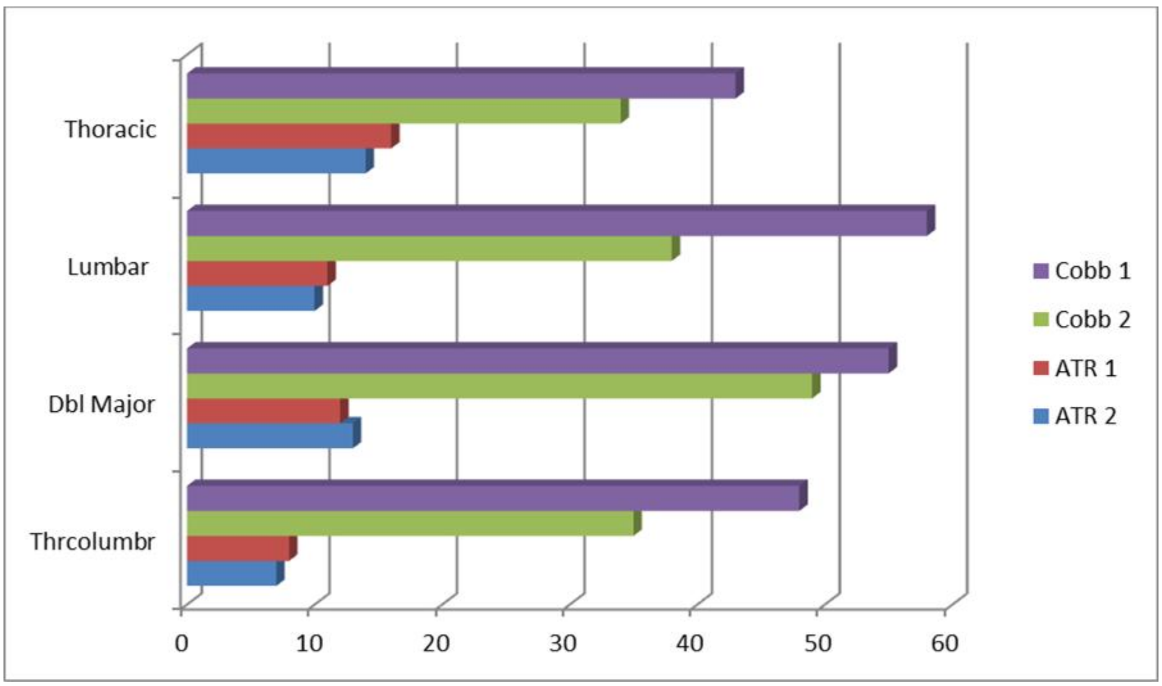
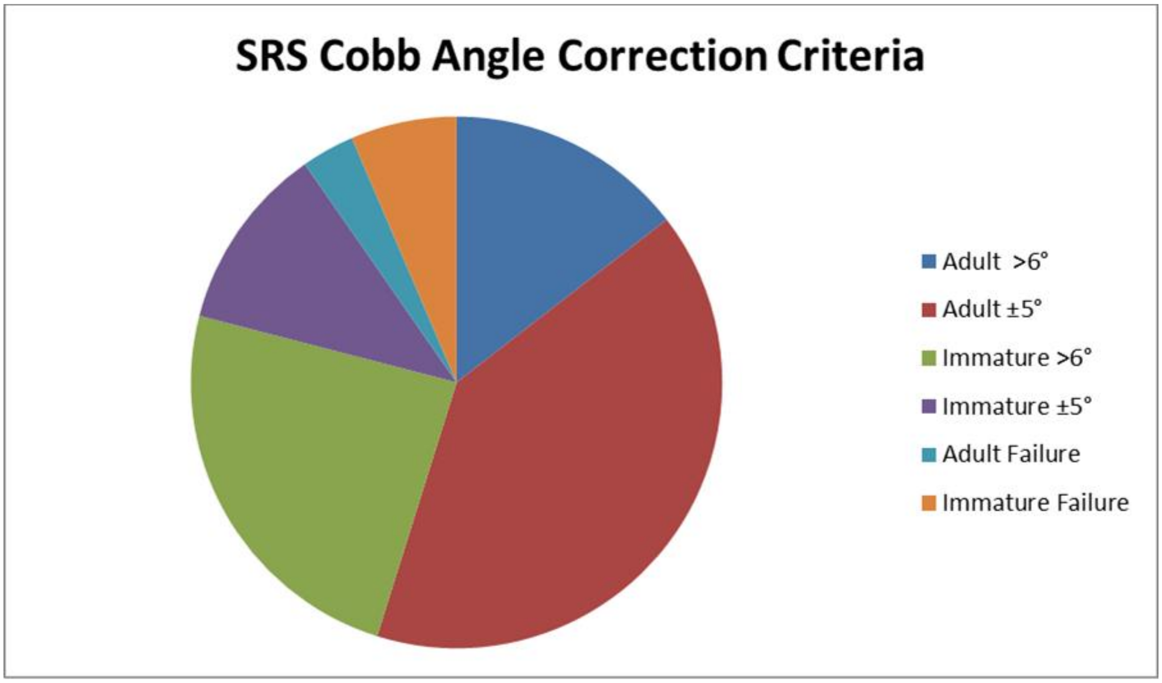


Table 5


SRS Cobb Angle Correction Criteria
Adult >6°
Adult ±5°
Immature >6°
Immature ±5°
Adult Failure
Immature Failure