Experimental Research

The effectiveness of Schroth exercises added to the brace on the postural control of adolescents with idiopathic scoliosis: Case series

Yasin Larni a, Holakoo Mohsenifar a,⁎, Hasan Ghandhari b, Reza Salehi a

a Iranian Center of Excellence in Physiotherapy, Rehabilitation Research Center, Department of Physiotherapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran
b Bone and Joint Reconstruction Research Center, Shafa Orthopedic Hospital, Iran University of Medical Sciences, Tehran, Iran

ARTICLE INFO

Keywords:
Adolescent idiopathic scoliosis
Schroth method
Static balance
Postural control
Angle of trunk rotation

ABSTRACT

Background: One of the disorders that may cause changes in body posture and impair postural control is adolescent idiopathic scoliosis (AIS). Scoliosis-specific exercises, such as the three-dimensional Schroth method added to the brace, may be able to help these patients improve their postural control. The aim of this study was evaluating the effect of Schroth physiotherapy scoliosis-specific exercises added to the brace on AIS patients' postural control.

Patients and methods: It is a case series study on twenty-three AIS patients. They were treated using the Schroth method and brace for three months, with the first five sessions lasting two weeks and subsequently one session per week. Postural control assessments include center of pressure (COP) range and COP velocity in the anteroposterior (AP) and mediolateral (ML) directions, and the COP sway area in the standing position with opened eyes and closed eyes by the force plate. The angle of trunk rotation (ATR) was assessed by the scoliometer. The methods are consistent with the PROCESS 2020 guidelines.

Results: The Schroth method and brace also significantly improved the variables of postural control variables in terms of COP range (p < 0.001), COP velocity (p < 0.001), and COP sway area in standing positions with opened and closed eyes (p < 0.001, p < 0.001) as well as ATR (p < 0.001) in AIS patients.

Conclusion: Schroth method and brace improved the postural control and trunk rotation of AIS patients.

1. Introduction

Adolescent idiopathic scoliosis (AIS) is a three-dimensional deformity of the spine that affects the shape and condition of the chest and trunk [1]. The cause of scoliosis has not yet been recognized and is being sought in inherited or acquired disorders of the spinal structure [2,3]. The prevalence of AIS with a Cobb angle greater than 10° is 0.93–12% [4,5], and its incidence varies according to geographical location [5,6].

If the progression of scoliosis is not prevented and treated in order to improve it, it can lead to problems such as limitations in the biomechanical function of the chest, changes in body posture, and defects in postural stability [7,8]. Biomechanical changes include deviations in the curvature of the spine and changes in the direction of the head, shoulders, scapula, and pelvis in three planes, which may lead to impaired postural stability [9], and this disorder in postural control is more pronounced in the trunk [10,11]. Changes in the relationship between body segments and muscle imbalances on both sides of the spine affect muscle function. Achieving a completely vertical position is also impaired in scoliosis, resulting in changes in the center of mass (COM), so that the torque of the corrective muscles in the trunk and lower limbs is necessary to maintain the stability of the body [12]. Perceptions and interpretations of sensory stimuli in AIS appear to have changed, interfering with the choice of appropriate motor response [12]. Consequently, scoliosis is associated with changes in mediolateral (ML) and anteroposterior (AP) position, as well as the sway area and velocity of the COM [13]. A set of center of pressure (COP) control variables and spinal posture have also been found to have a substantial association [14]. This indicates that the postural stability of scoliosis patients is weaker than that of a healthy control group of comparable age [15–17].

So far, various therapies such as braces, traction, biofeedback, exercise, and surgery have been used to treat AIS [1,18]. Society on Scoliosis Orthopedic and Rehabilitation Treatment (SOSORT) recommends specific scoliosis exercises as a standard treatment at angles less than 45° next to the brace [1,19,20]. There are various exercises for

⁎ Corresponding author.
E-mail addresses: Mohsenifar.h@iums.ac.ir, Mohsenifarpt@gmail.com (H. Mohsenifar).

https://doi.org/10.1016/j.amsu.2022.104893
Received 11 July 2022; Received in revised form 10 October 2022; Accepted 7 November 2022
Available online 13 November 2022
2049-0801/© 2022 The Authors. Published by Elsevier Ltd on behalf of IJS Publishing Group Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
scoliosis, including the Schroth treatment [21]. The three-dimensional corrective principles of the Schroth method include auto elongation, deflection, derotation, rotational breathing, and stabilization. In this method, muscle activation is achieved by activating some muscles that will help improve spinal correction, such as iliosposa, quadratus lumborum, latissimus dorsi, and erector spinae [22]. The patient also learns to correct spinal deformity through the help of sensory-motor feedback mechanism and corrective breathing patterns. In this breathing pattern, the patient directs the inhaled air to the concave area of the chest, and the ribs move in a convex direction with selective contraction of the trunk [22,23]. The effectiveness of Schroth treatment in reducing the Cobb angle has been demonstrated in recent studies [24,25].

Since scoliosis is associated with changes in mediolateral (ML) and anteroposterior (AP) position, as well as the sway area and velocity of the COP [13], and torque of the corrective muscles in the trunk and lower limbs [26], and as the Schroth method focuses on three-dimensional posture correction [22,23], the purpose of this study was to evaluate the effect of Schroth treatment method and brace on the control of static balance in patients with AIS.

2. PATIENTS and METHODS

2.1. Study design

This study was a case series on AIS patients that was performed in the biomechanics laboratory and physiotherapy clinic of the Department of Physiotherapy, Faculty of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran, between December 2019 and January 2021. The proposal of this study was approved by the ethics committee of Iran University of Medical Sciences on November 4, 2019 (IR.IUMS.REC.1398.804) and was registered in the Iranian Registry of Clinical Trial (IRCT2019072804618N3). This study was also registered to www.researchregistry.com (unique identifying code: researchregistry 8374). Before starting the study and after getting acquainted with the process and objectives of the study, informed consent was obtained from the participants and their parents in writing and orally. Our work has been reported in line with the PROCESS guideline [27].

2.2. Participants

Patients in this study were adolescents in whom AIS was diagnosed by a spine surgeon. The criterion for naming and classifying curvature of AIS patients in this study was based on the Schroth method. Inclusion criteria for AIS patients included: diagnosis of AIS, the age range of 10–18 years, a Cobb angle of 10-45°, main curvature in the right thoracic spine, a Risser sign of 0–5, no treatment during this study, which affects scoliosis, and the ability to attend weekly visits. AIS patients were excluded from the study if they had contraindications to exercise, mental health disorders, neuromuscular or rheumatic diseases, a history of spinal surgery, a surgical schedule, and nonidiopathic scoliosis. The characteristics of AIS patients are summarized in Table 1. Prior to the intervention and evaluation of posture control, patients were examined for joint pain, other musculoskeletal disorders, and other medical conditions.

The sample size of this study in AIS patients was determined based on a pilot study (initial n = 8) using the G*Power Statistical Package (version 3.0.10) with an α value of 0.05 to achieve a statistical power of 0.80 and an effect size of 0.69. This was the smallest effect size of variables based on the mean and standard deviation of the COP range (COPr) in AP direction in standing position with opened eyes (21.83 ± 4.50 for pre-test and 18.81 ± 4.15 for post-test), which required a minimum sample size of 19. Considering the drop-out rate of 20% and aiming to increase the statistical power of the results, 23 AIS (18 girls and 5 boys) were recruited into the study.

2.3. Interventions

The course of treatment consisted of five 60-min sessions in the first two weeks of training and practice, followed by one weekly session for three months under the supervision of a physiotherapist at the clinic, with 30–45 min of daily exercises at home (Fig. 1). The intensity of the exercise program was gradually increased according to the performance improvement of each participant. During these three months, all patients wore a Boston brace for at least 16 h each day, according to the spine surgeon’s prescription, and the brace was removed during Schroth exercises. Therapeutic interventions were performed by a physiotherapist with five years of experience in treating AIS with the Schroth method and with an internationally recognized certificate from the Best Practice Schroth Institute.

Treatment adherence was measured as a percentage of the specified treatment sessions performed over the course of three months, and compliance was measured as a percentage of the number of exercises prescribed. Parents examined compliance control on a daily basis, and a physiotherapist reviewed compliance control on a weekly basis, using a logbook comprising a daily exercise schedule.

2.4. Measurements

Demographic information (age, sex, weight, height, BMI) was collected during interviews with participants. Cobb angle and angle of trunk rotation (ATR) were assessed by the spinal surgeon.

**Postural control**: A force plate (Kistler Group-Swiss, 40*60 cm, Type: 5691 A) was used to collect static balance variables. Data were collected at 100 Hz and filtered at 10 Hz (low pass Butterworth). The COP range (COPr) and COP velocity (COPv) in the anteroposterior (AP) and mediolateral (ML) directions were determined as postural control variables. The COP sway area (COPsa) was calculated as a 95% confidence ellipse area [28].

**Angle of trunk rotation**: The ATR was assessed with the scoliometer and Adam’s forward bend test. Patients were asked to bend forward, and

| Subject no. | Age | Sex | Risser sign | Cobb angle | Compensatory curve | Angle of trunk rotation |
|-------------|-----|-----|-------------|------------|-------------------|------------------------|
| 1           | 12  | Female | 1           | 25         | No                | 11.89                  |
| 2           | 11  | Female | 1           | 21         | No                | 9.74                   |
| 3           | 11  | Female | 1           | 24         | left              | 10.05                  |
| 4           | 10  | Female | 1           | 31         | No                | 13.87                  |
| 5           | 12  | Female | 1           | 27         | No                | 11.02                  |
| 6           | 12  | Female | 1           | 29         | No                | 12.84                  |
| 7           | 13  | Female | 3           | 25         | left lumbar       | 11.09                  |
| 8           | 13  | Male   | 2           | 27         | No                | 12.93                  |
| 9           | 14  | Female | 3           | 33         | left              | 13.33                  |
| 10          | 15  | Female | 3           | 35         | left lumbar       | 15.87                  |
| 11          | 11  | Male   | 1           | 37         | No                | 17.21                  |
| 12          | 13  | Female | 2           | 28         | No                | 11.50                  |
| 13          | 14  | Female | 2           | 26         | left lumbar       | 10.36                  |
| 14          | 12  | Female | 1           | 19         | No                | 8.64                   |
| 15          | 11  | Female | 1           | 28         | No                | 12.45                  |
| 16          | 13  | Female | 3           | 39         | No                | 19.66                  |
| 17          | 14  | Male   | 3           | 26         | left lumbar       | 11.54                  |
| 18          | 13  | Male   | 2           | 27         | left lumbar       | 12.33                  |
| 19          | 11  | Female | 2           | 35         | No                | 17.39                  |
| 20          | 15  | Male   | 3           | 35         | No                | 16.24                  |
| 21          | 12  | Female | 1           | 29         | No                | 12.88                  |
| 22          | 12  | Female | 1           | 32         | No                | 13.86                  |
| 23          | 12  | Female | 1           | 31         | No                | 13.79                  |
ATR (the angle between the horizontal plane and the plane passing through the posterior part of the trunk) was measured using the apical vertebrae of the curve and the maximum angle of trunk rotation was recorded [29].

2.5. Protocol

AIS patients were asked to stand on the force plate with their arms at their sides. As suggested by Dufvenberg et al. participants were placed at a distance of 23 cm and at an angle of approximately 30° on the support surface. AIS patients were advised to breathe normally and look directly at the white spot 1.2 m away at eye level [30]. The static test lasted 20 s and was performed in two conditions with opened eyes (OE) and closed eyes (CE) randomly. All tests accomplished out of brace. Each condition was tested three times, with a 2-min break between each test.

2.6. Statistical analysis

Statistical analysis was performed using IBM® SPSS (version 21.0 software, IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated for baseline demographics for the entire sample. The Shapiro-Wilk test was used for normality of all variables. Nonparametric

Fig. 1. Schroth physiotherapy specific exercises: A, 50X; B, Door handle; C, Muscle cylinder; D, Rotational sitting; E, 3D made easy.
Wilcoxon test was performed statistically for comparing postural control variables and ATR before and after the intervention of Schroth method and brace in AIS patients. Cohen’s d effect size index was used for each of the dependent variables after the intervention. Statistical significance was determined at a p value of <0.05.

3. Results

This study included 23 AIS patients for comparing the efficacy of Schroth method and brace on postural control in standing position with OE and CE. The mean age (year), weight (kg), height (m), and BMI (kg/m²) of the participants were 12.40 ± 1.27, 48.03 ± 9.06, 1.60 ± 0.11 and 18.51 ± 1.94, respectively. Other basic information about patients’ conditions, including age, sex, Risser sign, Cobb angle, type and level of curvature, ATR are shown in Table 1.

The comparison between the mean values of postural control variables in OE and CE, and ATR of AIS before and after three months of treatment in OE and CE are shown in Table 2.

There was a statistically significant difference in postural control variables before and after three months of therapeutic exercises. The COPr before treatment in the OE standing position in the ML and AP directions were 8.37 ± 3.47, respectively, compared to 15.96 ± 5.33 and 23.96 ± 8.75 after treatment (p = 0.001, p = 0.002). Also, the COPr before treatment in the standing position with CE in the directions of ML and AP were 21.62 ± 6.09 and 31.54 ± 11.08, respectively, compared to 15.96 ± 5.33 and 23.96 ± 8.75 after treatment (p = 0.001, p = 0.002). The COPr before treatment in the standing position with OE in the ML and AP directions were 8.37 ± 1.99 and 12.23 ± 3.47, respectively, compared to 6.50 ± 2.62 and 9.62 ± 3.71 after treatment (p = 0.001, p = 0.003). Also, the COPr before treatment in the standing position with CE in the directions of ML and AP were 21.62 ± 6.09 and 31.54 ± 11.08, respectively, compared to 15.96 ± 5.33 and 23.96 ± 8.75 after treatment (p = 0.001, p = 0.002).

Table 2
Comparison of mediolateral (ML) and anteroposterior (AP) center of pressure range (COPr), velocity (COPv), and sway area (COPsa) with closed eyes (CE) and opened eyes (OE) between before intervention (BI) and after intervention (AI) for adolescent idiopathic scoliosis (AIS). Also, comparison of angle of trunk rotation (ATR) for adolescent idiopathic scoliosis between BI and AI.

| Variables | AIS-BI | AIS-AI | Pre-post difference in change scores | p AIS-AI vs. AIS-BI | Effect size | Cohen’s d |
|-----------|--------|--------|-------------------------------------|---------------------|-------------|----------|
|           | Mean ± SD | Mean ± SD | Mean (95% CI) | | | |
| CE        |        |        |          | | | |
| COPr (mm) | ML 21.62 ± 15.96 | 5.65 | 0.001 | 0.98 |
|           | AP 31.54 ± 23.96 | 7.57 | 0.002 | 0.75 |
|           | ML 15.08 ± 11.08 | 7.57 | 0.002 | 0.75 |
|           | AP 15.34 ± 12.96 | 2.36 | 0.001 | 0.73 |
|           | ML 10.18 ± 11.08 | 2.36 | 0.001 | 0.73 |
|           | AP 4.60 ± 6.46 | 2.36 | 0.004 | 0.42 |
| COPsa (m²) | 554.86 ± 372.53 | 182.33 | 0.005 | 0.64 |
|           | OE COPr (mm) |        |          | | | |
|           | ML 18.82 ± 14.89 | 3.93 | 0.024 | 0.75 |
|           | AP 24.03 ± 20.40 | 3.62 | 0.018 | 0.64 |
|           | ML 8.37 ± 6.50 | 1.87 | 0.001 | 0.80 |
|           | AP 12.23 ± 9.62 | 2.61 | 0.003 | 0.72 |
|           | 412.72 ± 256.99 | 155.73 | 0.003 | 1.01 |
|           | 162.52 ± 145.45 | 248.91 | 0.001 | 0.68 |
|           | 13.06 ± 11.14 | 1.92 | 0.001 | 0.68 |
|           | ± 2.70 ± 2.87 | (1.23, 2.60) | | | |

SD: Standard deviation.
of ATR was observed in the Schroth exercise and brace group, this change was not statistically significant compared to the group that received only braces. It has been shown that there is a relationship between ATR, and the magnitude of the curvature and it directly affects the Cobb angle [39].

Since scoliosis patients have impaired postural control, any therapeutic exercise that simultaneously enhance spine alignment and postural control may be more helpful in treating scoliosis. Therefore, it is possible to determine the effect of various specific scoliosis exercises and braces on posture management in randomized clinical trial study.

There are several limitations to this study that should be noticed, such as the small sample size, which limits the generalizability of the study. In addition, the effect of Schroth method and brace on postural control was examined only in the static standing position and without control group. It is recommended that further examinations be done on the effect of Schroth method and brace on the stability of dynamic standing position and walking, which challenge the balance more.

In conclusion, based on the findings of this study, it can be concluded that Schroth exercises and brace reduce ATR, and improve postural control in AIS patients.

Funding

The authors received no financial support for the research and/or authorship of this article.

Ethical approval

The ethical committee of Iran University of Medical Sciences approved the study (Ethical code: IR.IUMS.REC.1398.804).

Consent

Before starting the study and after getting acquainted with the process and objectives of the study, informed consent was obtained from the participants and their parents in writing and orally.

Author contribution

Study concept or design: YL, HM; Data collection: YL; Data analysis or interpretation: RS, HGH; Writing the paper: YL, HM, RS.

Guarantor

Yasin Larni.

Declaration of competing interest

The authors declare no conflict of interest.

References

[1] S. Negrini, et al., 2016 SOSORT guidelines: orthopaedic and rehabilitation treatment of idiopathic scoliosis during growth, Scoliosis Spinal Disord 13 (2018) 3.
[2] T. Rotwielecki, et al., Conservative management of idiopathic scoliosis—guidelines based on SOSORT 2006 Consensus, Orthop. Traumatol. Rehabil. 11 (5) (2009) 379-395.
[3] E.S. Vassiladi, T.B. Grivas, A. Kaspiris, Historical overview of spinal deformities in ancient Greece, Scoliosis 4 (1) (2009) 6.
[4] T.B. Grivas, et al., SOSORT consensus paper: school screening for scoliosis. Where are we today?, Scoliosis 2 (1) (2007) 17.
[5] T.B. Grivas, et al., Association between adolescent idiopathic scoliosis prevalence and age at menarche in different geographic latitudes, Scoliosis 1 (1) (2006) 9.
[6] T.B. Grivas, et al., Geographic latitude and prevalence of adolescent idiopathic scoliosis, Stud. Health Technol. Inf. 123 (2006) 84.
[7] R.L. Barrack, et al., Proprioception in idiopathic scoliosis, Spine 9 (7) (1984) 681–685.
[8] P. Hermann, et al., Idiopathic scoliosis and the central nervous system: a motor control problem. The Harrington lecture, Scoliosis Research Society. Spine 10 (1) (1983) 1–14, 1985.
[9] S. Sahl, et al., The effects of backpack load and carrying method on the balance of adolescent idiopathic scoliosis subjects, Spine J. 13 (12) (2013) 1835–1842.
[10] F. Gigetti, et al., Body schema disturbance in adolescence: from proprioceptive integration to the perception of human movement, J. Mot. Learn. Dev. 1 (3) (2013) 49-58.
[11] C. Assante, et al., Development of postural control in healthy children: a functional approach, Neural Plast. 12 (2–3) (2005) 109–118.
[12] D.C. de Abreu, et al., What is the influence of surgical treatment of adolescent idiopathic scoliosis on postural control? Gait Posture 36 (3) (2012) 586–590.
[13] K.F. Zabjek, et al., Estimation of the centre of mass for the study of postural control in Idiopathic Scoliosis patients: a comparison of two techniques, Eur. Spine J. 17 (3) (2008) 355–360.
[14] S. Pasha, K. Baldwin, Are we simplifying balance evaluation in adolescent idiopathic scoliosis? Clin. BioMech. 51 (2018) 91–98.
[15] N.N. Byl, et al., Postural imbalance and vibratory sensitivity in patients with idiopathic scoliosis: implications for treatment, J. Orthop. Sports Phys. Ther. 26 (2) (1997) 60–68.
[16] T. Sahli, et al., Bilateral factors as predictors of the prognosis in adolescent idiopathic scoliosis, Clin. Orthop. Relat. Res. 152 (1980) 232–236.
[17] K. Yamada, et al., Etiology of idiopathic scoliosis, Clin. Orthop. Relat. Res. (184) (1984) 50-57.
[18] H.-R. Weiss, et al., Physical exercises in the treatment of idiopathic scoliosis at risk of brace treatment-SOSORT consensus paper 2005, Scoliosis 1 (1) (2006) 6.
[19] S. Negrini, et al., Italian guidelines on rehabilitation treatment of adolescents with scoliosis or other spinal deformities, Eur. Mediproc. 41 (2) (2005) 183.
[20] J. Bettany-Saltikov, et al., Physiotherapeutic scoliosis-specific exercises for adolescents with idiopathic scoliosis, Eur. J. Phys. Rehabil. Med. 50 (1) (2014) 111–121.
[21] H. Biderlshevsky, et al., Physiotherapy scoliosis-specific exercises - a comprehensive review of seven major schools, Scoliosis Spinal Disord 11 (2016) 20.
[22] C. Lehnert-Schroth, D.A. Smith, Three-dimensional Treatment for Scoliosis: Physiotherapeutic Method for Deformities of the Spine, Martindale Press, 2007.
[23] C. Lehnert-Schroth, Introduction to the three-dimensional scoliosis treatment according to Schroth, Physiotherapy 78 (11) (1992) 810–815.
[24] T. Kuru, et al., The efficacy of three-dimensional Schroth exercises in adolescent idiopathic scoliosis: a randomised controlled clinical trial, Clin. Rehabil. 30 (2) (2016) 181–190.
[25] S. Schreiber, et al., Schroth physiotherapeutic scoliosis-specific exercises added to the standard care lead to better Cobb angle outcomes in adolescents with idiopathic scoliosis - an assessor and statistician blinded randomized controlled trial, PLoS One 11 (12) (2016), e0168746.
[26] M. Simonene, et al., Altered sensory-weighting mechanisms is observed in adolescents with idiopathic scoliosis, BMC Neurosci. 7 (1) (2006) 68.
[27] R.A. Agha, C. Sohrabi, G. Mathew, T. Franchi, A. Kerwan, O.PROCESS Group, the PROCESS 2020 guideline: updating Consensus preferred reporting of Case series in surgery (PROCESS) Guidelines, Int. J. Surg. 84 (2020) 231–238.
[28] T.E. Prieto, et al., Measures of postural steadiness: differences between healthy young and elderly adults, IEEE Trans. Biomed. Eng. 43 (9) (1996) 956-966.
[29] L.E. Amendt, et al., Validity and reliability testing of the Scilometer®, Phys. Ther. 70 (2) (1990) 108–117.
[30] M. Dulvenberg, et al., Does postural stability differ between adolescents with idiopathic scoliosis and typically developed? A systematic literature review and meta-analysis, Scoliosis and spinal disorders 13 (1) (2018) 19.
[31] M.-L. Nault, et al., Relations between standing stability and body posture parameters in adolescent idiopathic scoliosis, Spine 27 (17) (2002) 1911-1917.
[32] B. Sawatzky, S. Tredwell, D. Sanderson, Postural control and trunk imbalance following Cotrel-Dubousset instrumentation for adolescent idiopathic scoliosis, Gait Posture 5 (2) (1997) 116–119.
[33] R.G. Burwell, et al., Pathogenesis of idiopathic scoliosis. The Nottingham concept, Scoliosis 8 (19) (1992) 68.
[34] C.J. Goldberg, et al., Surface topography, Cobb angles, and cosmetic change in scoliosis, Spine 26 (4) (2001) E55–E63.
[35] L. Ramirez, et al., A support vector machines classifier to assess the severity of idiopathic scoliosis from surface topography, IEEE Trans. Inf. Technol. Biomed. 10 (1) (2006) 84-91.
[36] S. Bidari, et al., Effect of exercise on static balance and Cobb angle during the weaning phase of brace management in idiopathic scoliosis and hyperkyphosis: a preliminary study, J. Back Musculoskelet. Rehabil. 32 (4) (2019) 639-646.
[37] H. Kocaman, et al., The effectiveness of two different exercise approaches in adolescent idiopathic scoliosis: a single-blind, randomized-controlled trial, PLoS One 16 (4) (2021), e0249692.
[38] K.Y.H. Kwan, et al., Effectiveness of Schroth exercises during bracing in adolescent idiopathic scoliosis: results from a preliminary study-SOSORT Award 2017 Winner, Scoliosis Spinal Disord 12 (2017) 32.
[39] H.-H. Ma, et al., Application of two-parameter scolometer values for predicting scoliotic Cobb angle, Biomed. Eng. Online 16 (1) (2017) 1–13.